THE CUTANEOUS GLOMUS AND ITS TUMOUR.

THESIS FOR THE DEGREE

OF

MASTER OF SURGERY

PRESENTED BY

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PART III

INTRODUCTION

Ever since the discovery of the circulation of the blood by Harvey 300 years ago, physiologists considered the capillaries as the only normal link through which the blood could pass from arteries to veins. Direct connections between the arteries and veins had however been observed but were of the nature of arterio-venous fistulas, that is abnormalities rather than physiological structures. Authors occupying themselves with the mechanism of the normal circulation had actually expressed the view that direct communications between arteries and veins, other than capillaries would result in a breakdown of the circulation (Mall 1896, Thoma 1892). Nevertheless descriptions of normally existing direct pathways between arteries and veins gradually made their appearance in the scientific literature during the last century. (Sucquet, Hoyer, Grosser and others). To these structures, the name arterio-venous anastomoses and neuro-myo-arterial glomus had been applied. Since then a great deal of work has been done on the histology and the anatomy of the neuro-myo-arterial glomus or glomus body. Despite this big gaps still remain in our knowledge of this subject.

It is difficult to understand why so little reference is made in modern anatomical and physiological text books to this well recognised and important structure.

In presenting this thesis an attempt was made to give a clear conception of the glomus during health and disease. In order to do this, a thorough histological and anatomical knowledge was necessary. To achieve this numerous serial sections of

glomus bodies in the nail-bed were studied and one series reconstructed in wax. A clear picture of the glomus body in all its dimensions and its relation to the neighbouring structures was produced. Apart from interesting physiological points, other aspects of the digital circulation were also revealed.

To the pathologist the glomus body is of interest since it gives rise to a benign tumour which is still regarded by many as an interesting rarity. The fact that a typical case was recently presented at a final examination in Surgery and the correct diagnosis was suggested by only 1 of 50 candidates, supports this contention. (Year Book of Surgery 1946).

An attempt has been made in this study to give a clear clinical picture of the tumour with the addition of histories and investigations of 8 cases. Some were investigated personally while others could only be followed up and their histology studied. The relation of the tumour to the normal glomus body was demonstrated by the similarity of the histological features. The congenital arterio-venous anastomoses of a limb and the leiomyoma were also mentioned and an example of each given to demonstrate their close physiological and histological relationship to the glomus tumour.

A most useful adjunct to clinical investigation was the van Slyke's Manometric Apparatus by which an accurate estimate of volume per cent. of oxygen in the blood could be determined. It took a great deal of patience and observance of the smallest detail to master this apparatus but proved a useful aid in the diagnosis of painful tumours of the cutaneous region of the extremities. Finally the literature has been carefully reviewed and the work and opinions of well-known scientists analysed.

PART 1.

A. HISTORY OF NORMAL GLOMUS OF SKIN AND SUBCUTANEOUS TISSUE

Pierre Masson in his book on Glomus Tumours (Les Glomus Neurovasculaires 1937), mentions that Lealis-Lealis discovered communications between spermatic arteries and veins in 1707. In 1719 Winslow made mention of similar connections existing between oesphageal artery and pulmonary vein, and also between left bronchial arteries and azygos vein. Debierre and Gerard confirmed this later (1895 - 1897).

An arterio-venous anastomoses in erectile organs was described, for the first time, by Berres in 1837. Further work was done on these organs by Müller in 1844. He found similar communications.

The cutaneous Glomus system was not understood until 1862, when Sucquet performed experiments of injecting dye into arteries of the hands and feet. He was surprised to see the dye appearing in the veins before the capillary network was filled. In looking for an independent pathway he discovered slender, anastomotic vessels. These vessels were tortuous and most abundant in the nailbed, pulp of finger and palm of the hand. The authenticity of his findings was strongly contested.

In the same year Hyrtl identified structures in the wing of the bat which emptied directly into the veins from arteries.

In 1867 J. Arnold described "glomeruli caudales" of dog, cat and rabbit, which he considered homologous with

glomus coccygeum (gland of Luschka) of man.

From 1872 - 1877 H. Hoyer resumed and furthered the study of arterio-venous anastomoses. He used a slimy mixture consisting of alcoholic solution of shellack and silver nitrate which passed through the arteries readily, but only with difficulty through the capillaries. He confirmed the work of Sucquet but also demonstrated the existence of arterio-venous anastomoses in the ear, nose, lips, tail and penis of monkeys, cats and dogs. It is interesting to record that the name Sucquet-Hoyer canal was later given to the anastomotic channel.

In 1875 F. Berlinerblau failed to find the connections described by Sucquet, considering them to be capillaries.

Bouceret (1885) repeating Sucquet's work, found arterio-venous amastomoses in pulps of fingers, nail-bed, thenar and hypothenar eminences.

Gehberg (1885) and Golubew (1893) described arterio-venous anastomoses in kidney capsule.

In 1895 Gerard used the term "arterio-venous anastomoses". He found anastomoses 0.4 to 3.0 millimetres in diameter at the bends of the joints and between aorta and inferior vena cava in monkeys.

To O. Grosser we owe a great deal for his histological studies of the normal anastomoses. In 1901-1902 he found that there were arterio-venous channels in the fingers

toes of man and in the wings of the bat. He defined their relations and exact form with the help of wax reconstruction by Born's method. He found that in bats the inside diameter was 40-150 Microns and outside diameter 90-280 Microns. In man they measured 10-30 Microns on the inside and 55-150 on the outside. With his reconstruction he found that the muscle wall consisted of an inner longitudinal and outer oblique layer. He found the internal elastic lamina missing and emphasized the rich nerve supply to these anastomoses.

Vastarini-Cresi (1902) confirmed the descriptions of Grosser.

In 1904 Walker concluded that glomus cells were true epithelial cells and argued that the coccygeal and cutaneous glomus bodies be grouped with the ductless glands.

S. van Schumacher (1907) studied them in birds and men. He pointed out their resemblance to caudal glomerulus of Arnold. This body occurs in mammals possessing tails and is situated on the ventral aspect of each caudal vertebra. Phylogenetically, they represent the Glomus Coccygeum or Luschka's gland. The latter occurs as small oval body on the anterior aspect of sacrum and will be mentioned later.

In the same year Stoerck failed to find Chromaffin tissue in the glomus coccygeum as well as any histological relation to sympathetic nervous system.

Nussbaum (1912) described arterio-venous anastomoses in the pericardial vessels but did not find epithelial cells.

Muller and Godfrey (1917) found arterio-venous anastomoses in the posterior abdominal region of a cat.

In 1922 Clara found direct connections between the arteries and the cavernous sinuses of the penis, originally described by Muller in 1835.

In 1924-1926 P.Masson conducted the study of the digital anastomoses and found them richly supplied with muscle and nerve tissue. Consequently, the name "neuro-myo-arterial glomus" was given to them. At the same time he worked on the pathological aspect of the digital glomus.

In 1927 Max Clara wrote an interesting monograph on the glomus. He studied the histology of the wall of arterio-venous anastomoses in birds and mammals and found that the coiled ones had epithelioid modifications of muscle cells while straight ones did not. He stressed absence of elastica interna, the importance of which will be shown later.

In Testut's anatomy (1929) arterio-venous anastomoses were described in pia mater of brain.

In 1932 Spanner demonstrated arterio-venous anastomoses in the intestine and counted six hundred arterio-venous anastomoses per square centimetre of the intestinal mucosa. In 1937 the same author demonstrated arteriovenous anastomoses in the kidney, connecting the glomerular artery with the glomerular vein, which meant that they were short-circuiting the blood flow to the glomeruli.

In 1937 Brown described arterio-venous anastomoses in the

dog's tongue, emphasizing the presence of a rich nerve supply, consisting of thin unmyelinated fibres with terminations in the media and thick myelinated fibres with terminations in the adventitia.

The physiological aspect of the glomus system was only entered into after 1930. We owe this work to Grant, Bland and R. and E.L.Clark. In 1938 the latter workers described the anastomoses in the living rabbit's ear, as seen by specially constructed windows.

In 1936 Goetz described changes in the uterine artery in the pregnant uterus of hedge-hog found in Madagascar. The arteries assumed the characteristics of the typical arterio-venous anastomoses.

Apart from glomus tumours, histological studies of the glomus in cellulitis of limb, arteriosclerotic gangrene diabetes and Buerger's disease were carried out by Popoff in 1934.

B. EMBRYOLOGY OF ARTERIO-VENOUS ANASTOMOSES

When referring to text-books of anatomy and embryology, no mention is made of the embryology of arterio-venous anastomoses.

Von Schuchmacher (1907) mentions however that they are found as early as the 52nd day of foetal life.

In the study of the development of the vascular system we find that blood-vessels, which are derived from the mesodermal layer first make their appearance in three regions:-

(a) On the surface of the yolk sac.

(b) In the body stalk, and

(c) In the chorion.

The cells of the mesoderm become arranged into solid strands or cords which join to form a network or syncytium, the area vasculosa, which covers the entire yolk-sac. Fluid collects within these strands converting them into vacuoles which gradually enlarge but leave narrower connecting cords between them. These narrow cords become canalised and form a network of small vessels over the yolk-sac. Later this network becomes differentiated into flattened cells which compose the

wall of the capillaries. Elsewhere in the body the earliest vessels are formed in a similar manner. It therefore suggests that the network of cords between the vessels are of the nature of fistulae or arterio-venous anastomoses.

If this hypothesis is correct, one can assume that the majority of these connections will disappear but some will persist in post-natal life and occur in different parts of the body. Thus the cutaneous glomus bodies will be confined to the small vessels of the extremities, while the deep arterio-venous anastomosis will be found in the intestines and kidneys. The persistence of larger anastomotic vessels of the extremities will give rise to the condition of congenital arterio-venous anastomosis.

Reid (Arch. Surg. 1925) mentions that arteries and veins develop from a common vascular bed. Enormous constructive as well as destructive changes are necessary before the final pattern is reached. He is surprised therefore, that congenital abnormal communications do not occur more frequently.

Masson (1924) has tried to explain the presence of glomus tumours in unusual situations, on a congenital basis. He attributes them to presence of misplaced glomus tissue in those situations. Perhaps the postnatal persistence of these vascular connections in a part of the body where they do not normally occur, may be a more reasonable explanation.

C. THE ANATOMY AND HISTOLOGY OF NORMAL GLOMUS BODY

The digital arteries in their course along the lateral borders of the digits give off numerous small subcutaneous branches which run in the subcutaneous tissue parallel to the surface of the skin. From these subcutaneous arteries arise arterial branches which run towards the skin. At the inner border of the stratum reticulare they divide into two branches. The larger branch turns at right angles and runs parallel to the skin, whilst the smaller branch continues onwards towards the surface (Popoff, 1934).

It is this smaller branch or preterminal artery with which we are most concerned. In the stratum reticulare it gives off the afferent arterioles to the glomus bodies and continues onwards to supply the papillary layer of the skin. (Fig 1).

The glomus body is made up of the following structures:

1. Afferent arteriole.
2. The anastomotic vessel
3. The primary collecting vein.

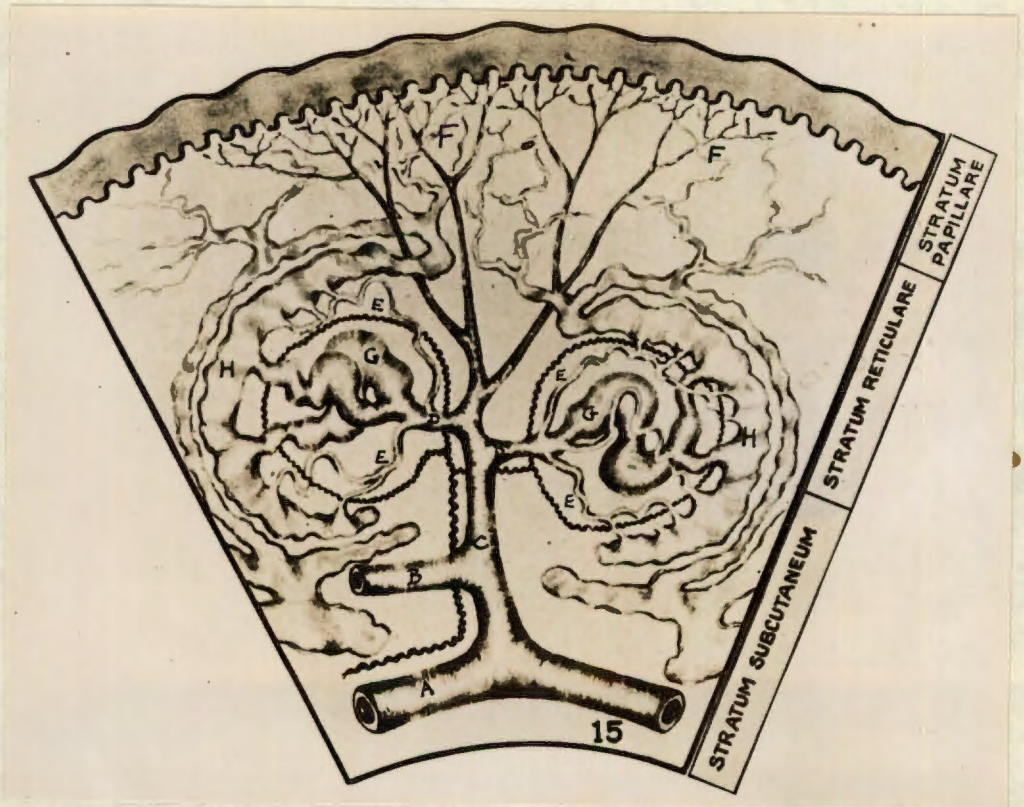


FIG.1
SCHEMATIC RECONSTRUCTION OF DIGITAL CIRCULATION
(After POPOFF 1934)

A. Subcutaneous Artery
B. Larger Branch
C. Smaller Branch or Preterminal Artery
D. Afferent Arteriole
E. Preglomic Arteriole
F. Capillary Bed
G. Glomus Body
H. Collecting Vein.

1. The afferent Arteriole

The origin of this vessel from the pre-terminal artery has been described. It runs a short course, after which it becomes continuous with the anastomotic vessel. At this site very important changes take place in the wall of the arteriole. The internal elastic lamina ends abruptly and serves as a demarcating line between the afferent artery and the anastomotic canal. The lumen of the arteriole which is normally uniform becomes irregular at this junction and this serves as an additional landmark. Popoff, (1934), refers to this part as cushion-like endothelio-muscular elevations and attached a great deal of importance to them. He states that at this site the preglomic arterioles arise and these irregular folds in the endothelium assist to direct part of the circulating blood into these vessels. The preglomic arteriole traverses the glomic body and is the artery of supply to this structure. At no place does it link up with the anastomotic canal but ends in a capillary network in the glomus body. The wall is composed of a circular layer of muscle fibres surrounded by adventitia.

Each afferent arteriole gives rise to 1 to 4 anastomotic canals.

2. The Anastomotic Canal

The canal, also known as the Sucquet-Hoyer canal,

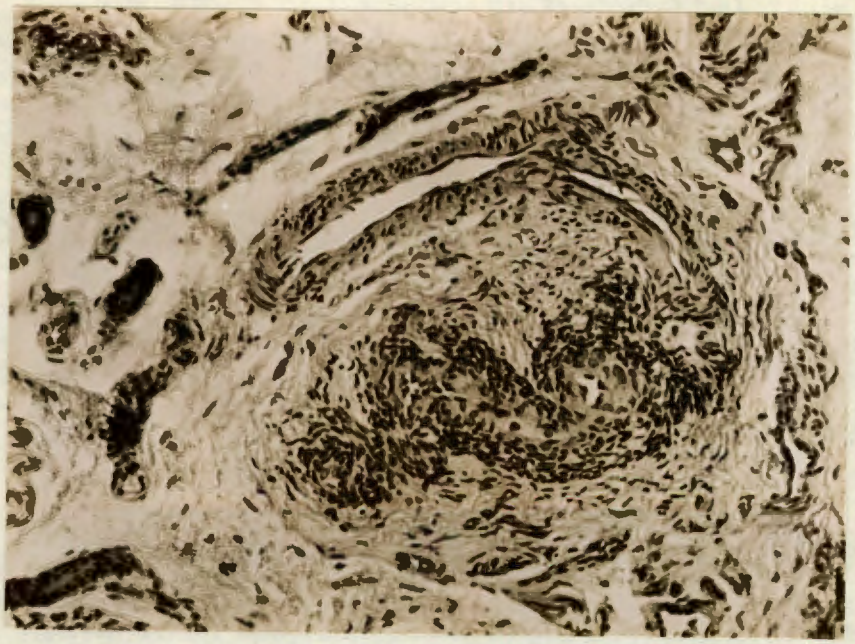


FIG.2 H & E X 150

An excellent example of the anastomotic canal of a Glomus body in longitudinal section. Note the marked tortuosity, thick wall and narrow lumen of the channel. Above the Glomus a large artery gives off a small afferent arteriole from which this Glomus arises.

is a very tortuous S-shaped channel linking the artery with the vein. (Fig. 2). In the resting state, the lumen is smaller than that of the afferent vessel and presents a stellate appearance on transverse section. The canal is lined by a single layer of endothelial cells and there is complete absence of an internal elastic lamina. (Fig. 5).

The wall of the canal is thicker than the afferent artery and is composed of glomus cells by which these bodies are readily recognised. (Figs. 3 and 4). They are polygonal cells with a clear cytoplasm and a dark staining round nucleus. On account of this appearance, they are often named epithelioid cells. These cells are present in several layers and extend from the endothelial to the adventitial layer. They are closely packed cells with absence of myofibrils and do not respond to stains for glycogen, fat or mucin. The nucleus shows no special tinctorial affinities and is poor in chromatin. Masson (1924) believes that they are modified muscle cells, since all stages from ordinary muscle cells to the epithelioid cells are found. He also mentions that in addition to glomus cells, the wall consists of an inner longitudinal and outer circular coat. He attributes the irregularity of the lumen to this longitudinal layer. Popoff (1934) who worked on 800 normal and abnormal histological blocks, found muscle in the wall of the canal but makes no mention of this

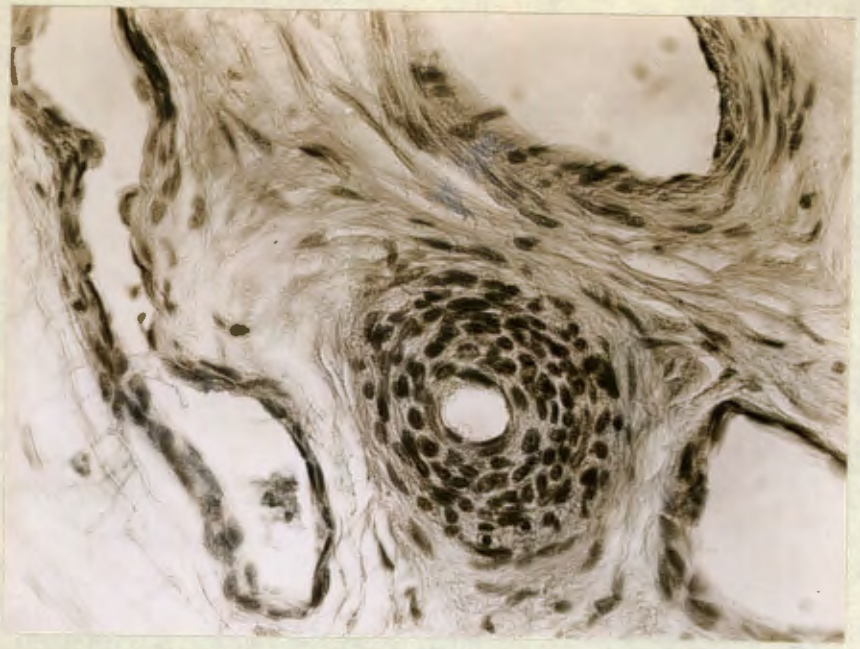


FIG.3

H&E X 375

Slide 176 Transverse Section through anastomotic channel showing typical rounded darkstaining nuclei of glomus cells closely packed. The lumen is dilated and lined by endothelial cells. The capsule of glomus is not well shown. In uppermost part of picture, portion of an artery can be seen. On either side of glomus two large veins are visible.

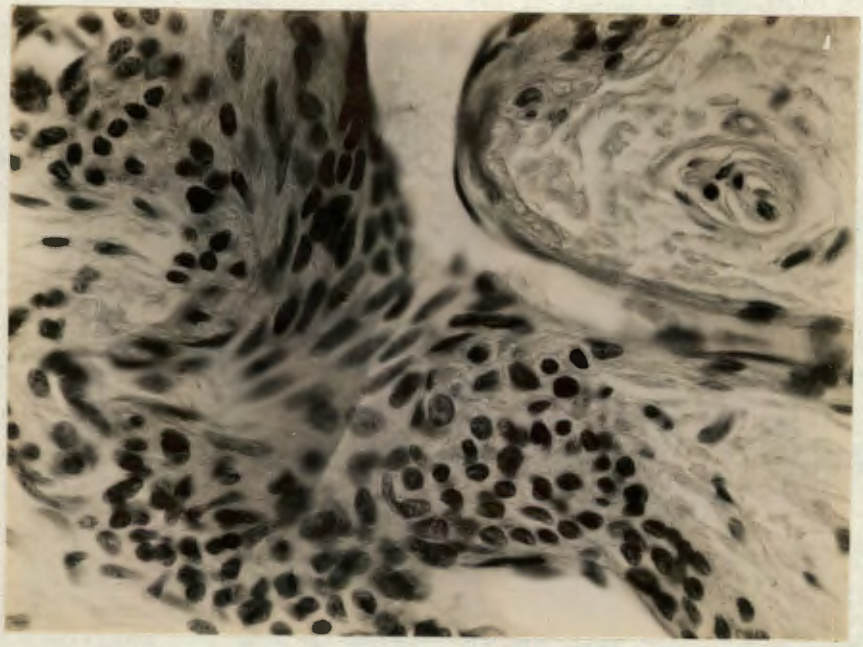


FIG. 4

H & E X 440

Slide 7o is a section through artery wall and Glomus The difference between nuclei of muscle and Glomus cells is shown. The former are smaller and spindleshaped.

longitudinal bundle,

The most notable feature of the glomus cells is their marked contractile and dilating powers. Thus they are capable of obliterating the anastomotic canal in a very short space of time, It has been demonstrated that an anastomosis with an inside diameter of 20 microns was obliterated within half a second. Clark (1938) described this feature after observing the circulation of rabbits' ears by means of specially constructed windows.

The measurements of the canal are as follows:

In Microns.	Nailbed	Pulp
Diameter (outside)	55-60	90-100
Lumen	18-22	10-20

RADASCH 1937

The lumen during life changes within wide limits. During contraction of the anastomosis the lumen may be obliterated, while it may equal 50 -60 microns during full dilatation.

3. Primary Collecting Vein (Fig.8. Slide 92)

The efferent portion of the canal loses its characteristic cells and passes into the primary vein. It is thin-walled, is poor in or devoid of muscle tissue and shows the presence of the internal elastic lamina. They

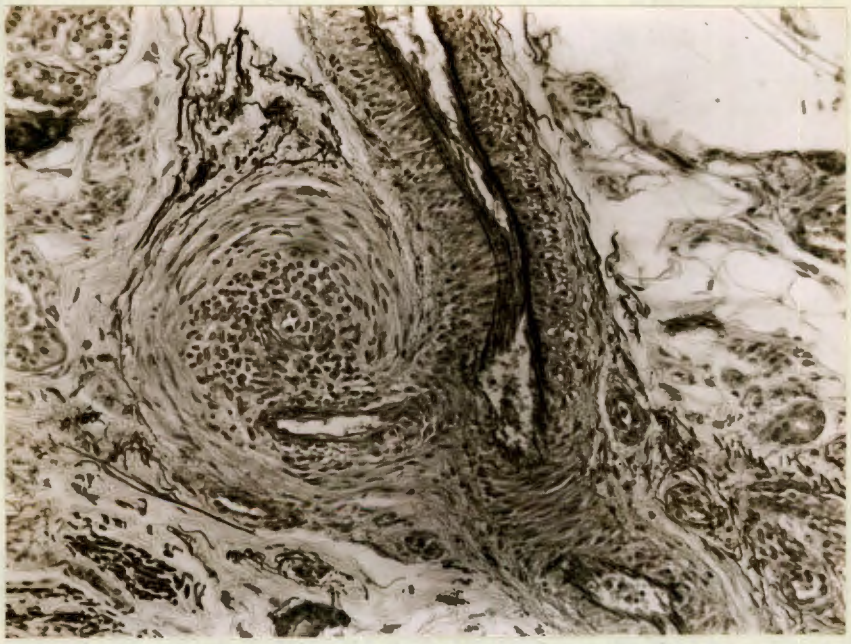


FIG.5 HART'S X 150

This shows the value of the elastic stain A vessel has been cut longitudinally and shows a dark band of elastic tissue under the endothelium. The small afferent arteriole on the left of this vessel, shows similar features. The Glomus body shows complete absence of elastic tissue. The thick collagenous capsule of glomus is particularly well shown.

empty into the subpapillary plexus and through this into into the deeper veins of the skin. Contrary to the views of anatomists, these small veins were shown to possess valves. The width of the primary collecting vein is 60-120 microns in width and 200 microns in length. In the reconstruction (Fig. 9 and 25) the primary vein has the shape of a broad ruffle or cape which encircles the glomus and forms a voluminous receptacle with a highly-developed surface area.

The whole glomus body is enclosed in a capsule of collagenous fibres. (Fig. 5).

The Nervous Innervation

Masson (1924 & 1937) has done a great deal of work in demonstrating the nervous connections of the glomus bodies. By various methods of staining he showed that the glomus body with its surrounding capsule was richly supplied by medullated and non-medullated nerve fibres. He has even demonstrated the connection of a glomus cell with a non-medullated nerve fibre. Subsequent workers have had great difficulty in confirming Masson's work.

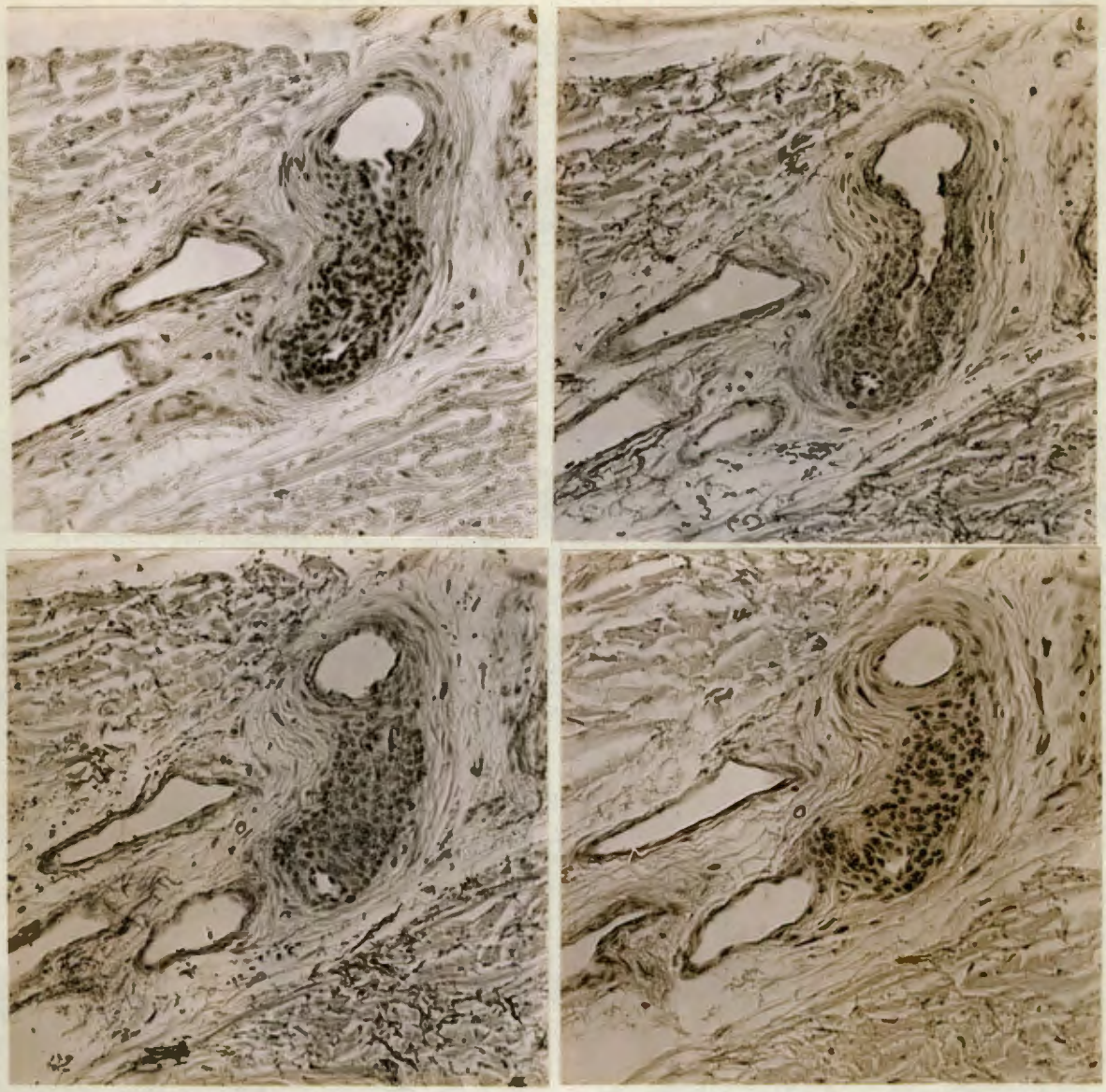
Popoff (1934) stated that the clear reticular zone surrounding the wall of the glomus body consisted of nerve fibres. (Fig. 13). This clear zone could be demonstrated in some of my sections but the differential nerve stains proved a great difficulty.

FIG.7 H & E X 85

(a) (b) (c)

Serial section from nail fold demonstrating the resemblance between Glomus bodies and sweat glands. In Section (a) the glomus in lower part of picture could readily be confused with a sweat gland in upper part of picture. In Sections (b) and (c) the structure of the glomus can be discerned. The sweat gland is recognised by its well defined basement membrane which is absent in the glomus. This illustrates the value of serial sections in histology.

95 94



93 92

FIG. 8 H & E X 150

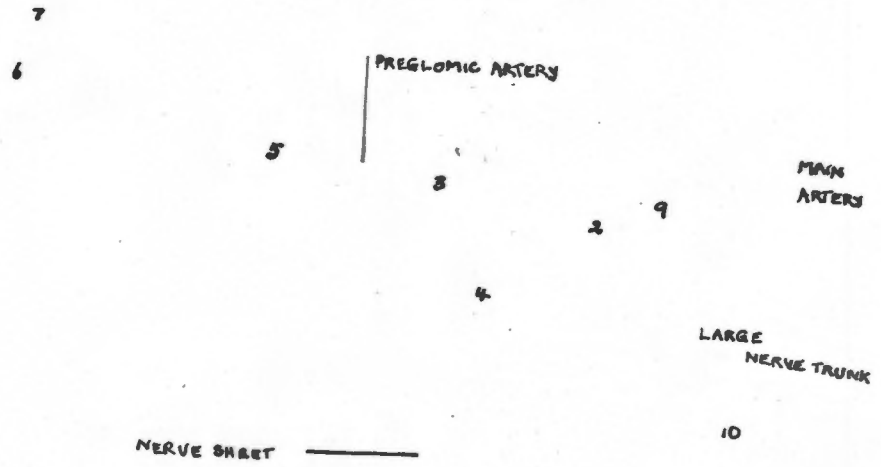
Serial sections 95 - 92 showing the origin of a glomus body from an artery and linking up with a vein. Note the thickness of the wall of the anastomotic canal and its narrow lumen when compared with artery and vein.

D. THE RECONSTRUCTION OF NORMAL GLOMUS

In 1924 Pierre Masson reconstructed the normal glomus by doing serial sections on fingers of man. He examined each slide microscopically and then did a schematic reconstruction of the glomus. (Fig. 10). This picture has been reproduced by various authors who interested themselves in this subject.

In studying this picture one finds certain features which are incompatible with the clinical picture produced by these bodies. For example, he shows the glomus bodies as beautiful coiled structures coming off an afferent arteriole and richly supplied by a nervous reticulum. The collecting veins, however, are very poorly depicted. They appear as small collapsed inconspicious organs in comparison with the glomus body. I make this criticism as I have proved that large venous connections exist on the efferent side of the glomus. His inability to show this feature will be explained later.

In 1901 Grosser did a wax construction of the cutaneous glomus of man, and in 1934 Popoff reconstructed the normal glomus by serial sections of fingers.


7
6
PREGLOMIC ARTERY
5
8
MAIN
ARTERY
9
2
4
LARGE
NERVE TRUNK
10
NERVE SHEET

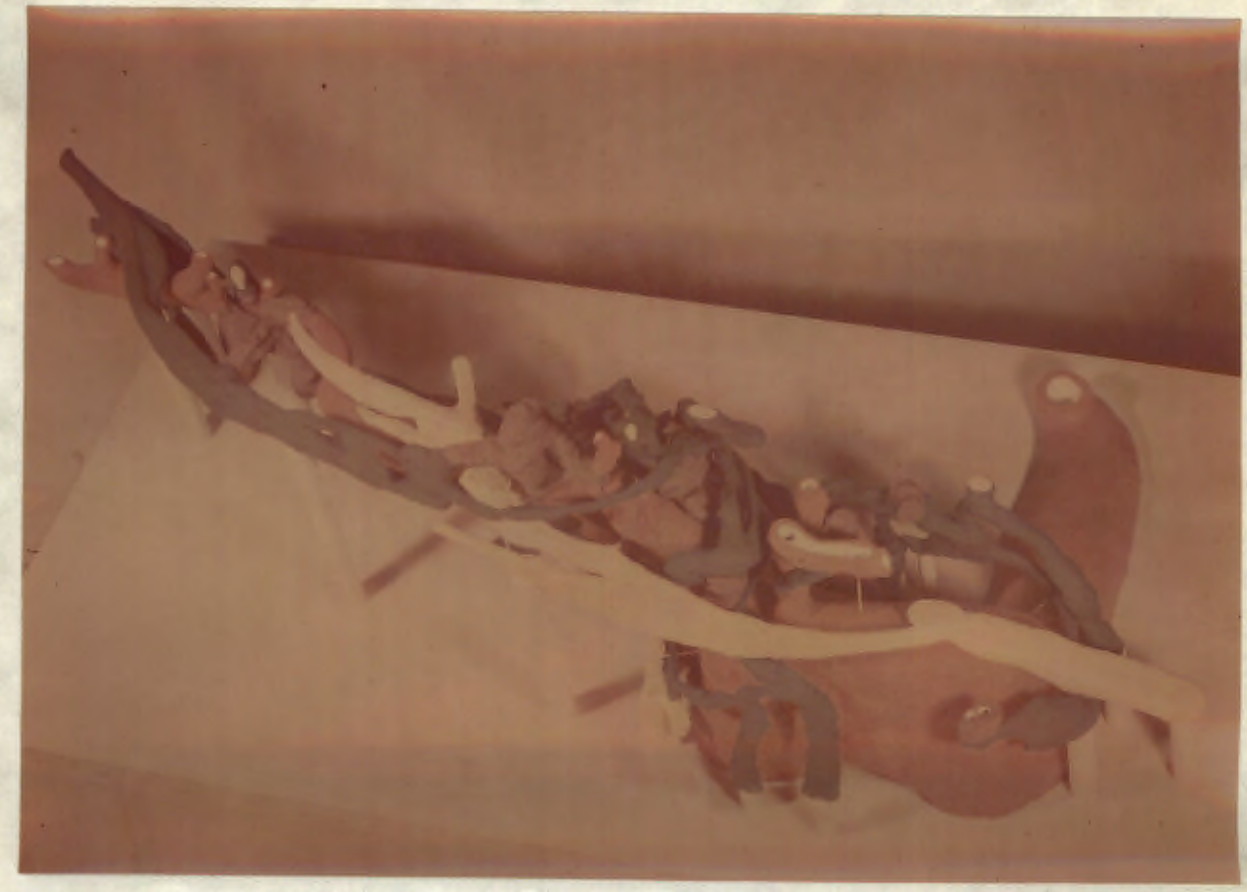


Fig. 9

Colour photograph of Model (from above).

Unfortunately, these two authors did not produce photographs of their models.

Popoff, in a recent article on the digital vascular system, gives an excellent histological account of the glomus body, but again reproduces a schematic reconstruction of the glomus system. (Fig. 1). His reproduction is superior to Masson's from point of view of the venous drainage which shows itself as a cuff surrounding the glomus body.

In my wax model (Fig. 9) reconstructed by serial sectioning, I have been fortunate enough to demonstrate 10 glomus bodies. Some are simple and easily followed, while others are of a more complex form.

THE MATERIAL USED FOR RECONSTRUCTION

The material used for reconstruction was a finger of a limb which had been amputated for carcinoma of back of hand. The limb was specially prepared by perfusing the ulnar and radial arteries with saline to wash all the blood out of the tissues. In order to distend the veins they were clamped and Bouin's solution was injected under pressure into the ulnar and radial arteries. After a suitable amount of Bouin's had been injected the arteries were tied off and the whole limb

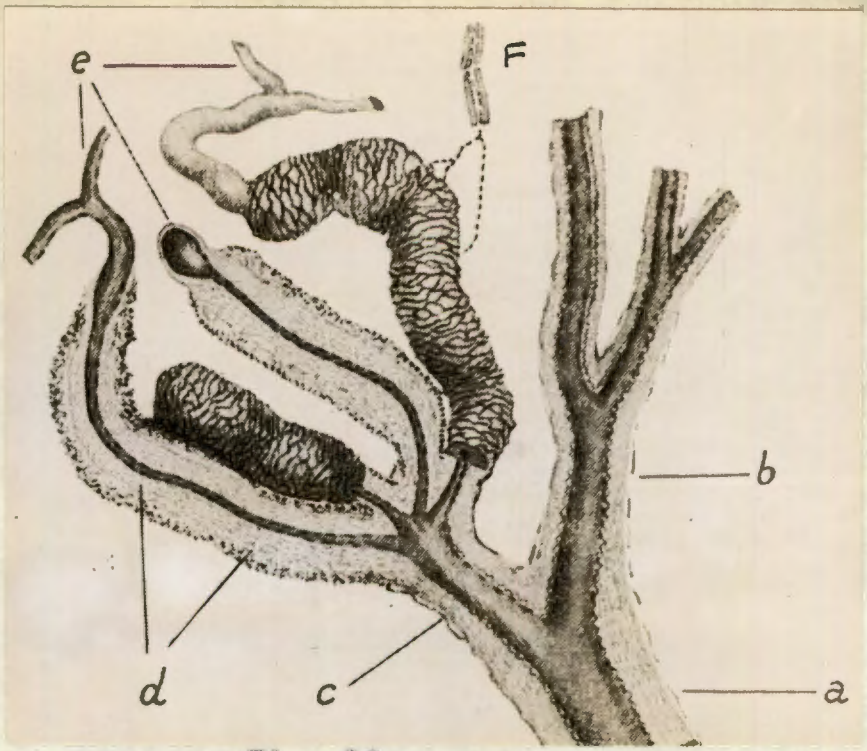


Fig. 10

Schematic reconstruction of normal glomus
(After Masson 1924).

a.....Cutaneous artery
b.....Preterminal artery
c.....Afferent arteriole
d.....Glomus body
e.....Collecting veins
f.....Not mentioned.

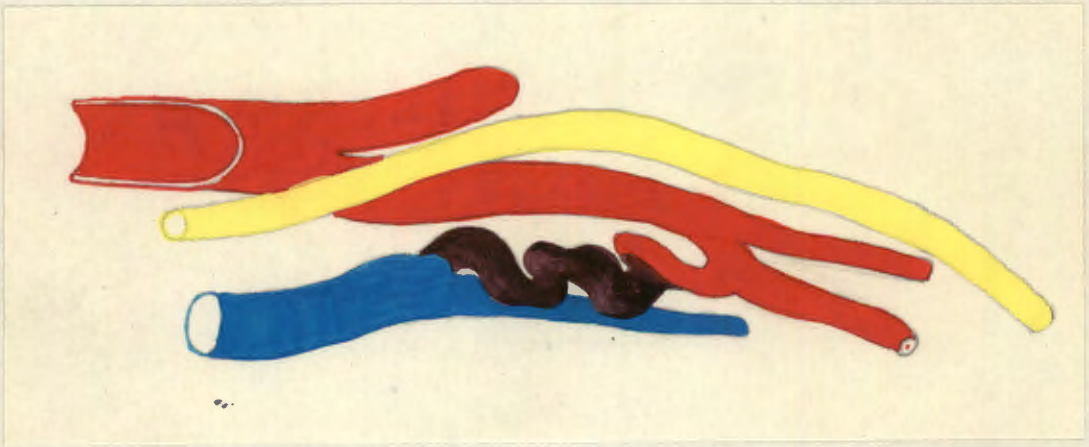


Fig. 11

Schematic reconstruction of a normal glomus of digit
(after Goetz 1940)
Note that the artery and vein are connected by means
of a coiled channel or arteriovenous anastomoses shown in purple
The nerve is in close approximation to these vessels.

was immersed in the same fixative. The importance of distension and intravascular fixation of the veins will be realised later.

The nail-bed was chosen for reconstruction purposes. Firstly, it is a part of the finger which is very richly supplied with glomus bodies, and secondly, the absence of sweat glands makes the work easier.

Pure beeswax was used and was found to be far superior to either paraffin wax or a mixture of paraffin and beeswax. Beeswax is not brittle and has a low melting point.

TECHNIQUE

Sections of the nail-bed were cut in a plane parallel to the surface of the finger. Popoff, (1934), who did several reconstructions, advocated this method but did not use the intravascular fixation method of the tissue.

Each section was cut 10 Microns in thickness and every consecutive section was studied and used in the building-up of the model.

In order to demonstrate a glomus of reasonable size a sample slide was enlarged to a size which appeared practicable for the reconstruction. By replacing the slide by a blood-counting chamber in the platform of the microscope, the image of a square was projected on to a table. As each square measured 1/5th Millimetre and

Fig. 12. H & E X 12.

Commencement of model (Slide 118) showing large artery cut longitudinally and forming base of model. Together with other vessels and glomus bodies (just visible) it forms a glomus compartment. Note another glomus compartment on the left.

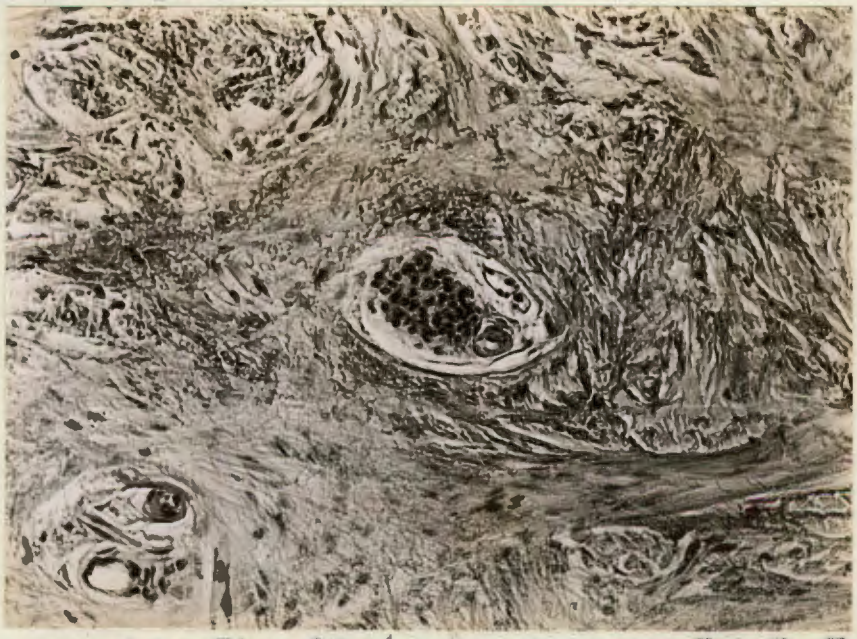


Fig. 13. H & E X 150

Surface of model showing termination of Glomus 5 (Slide 49). The glomus cells are surrounded by a clear zone. (Neuro reticular zone of Popoff). A preglomic arteriole and two venules are visible in this zone.

the image measured 70 millimetres our enlargement equalled $\frac{70}{1/5}$th. Our slides had therefore been enlarged 350 times.

Each section was carefully studied and the part of the slide containing well-marked glomus bodies was selected. These bodies were followed up in various slides making sure that the correct glomus was being studied. When a suitable series had been selected they were earmarked for drawing. The image of each section was thrown on to a table by means of a microscopic projector. Each picture was carefully traced, picking out the salient points in selected portions of the slide.

Special tracing paper, of sufficient transparency to allow one to see 6 to 10 drawings at a time, had to be used. Cellophane sheets, by virtue of their transparency and strength, served the purpose admirably. The slides had to be checked continually with a microscope.

On completion each drawing was coloured to show arteries, veins, glomus bodies and nerves. These drawings were then carefully superimposed to demonstrate the size, shape, structure, relations and direction of movement of the organs during reconstruction.

Each tracing was numbered and, by superimposing them, the whole scheme was put into book form. Seventy-two serial sections, commencing with slide 118 and ending with slide 46, were used and 150 tracings made on cellophane paper.

This book of drawings or "blue print" was traced on to greaseproof paper which is suitable for use on beeswax plates. The construction of wax plates added to one's difficulty. In addition, 50 - 60 pounds of beeswax, a very scarce commodity, was required. By repeated experimentation a very satisfactory plate 3.5 millimetres thick and measuring 24 x 9 inches was produced. This corresponded to an enlargement 350 times the thickness of the section. On the Continent these plates are manufactured by firms who can supply the required size on order.

The drawing on greaseproof paper was applied to the wax plate. Each structure was carefully cut out and bridges used to connect the different structures. This assured accurate relationship and localization of the structures.

On account of the complex nature of glomus 7 and its connecting veins this portion had to be built separately and attached to the original model afterwards.

The greatest difficulty encountered was the construction of the veins, particularly the smaller ones, which were thin-walled tortuous structures. For this reason lumina were not cut into the veins, as the stability of the model would have been jeopardised. One can appreciate this point on studying the model itself.

Another difficulty encountered was the breaking of tissue by sectioning, which caused slight displacement of organs. The amount of damage, however, was minimal and every structure in the serial sections could be traced and followed. Each reconstructed portion of wax was carefully joined and the model smoothed over on the surface , was ready for painting.

The arteries were painted red, the veins turquoise blue and the nerves yellow. (Fig. 9) Purple was deemed to be the most suitable colour for the glomus bodies, as there is usually some intermingling of arterial and venous blood in the anastomotic channel.

Measurements of model and corresponding tissue of the nailbed

	Model	Tissue
Length	3.5.Feet	3.0 Millimetres
Breadth	1.5 feet	1.3 Millimetres
Height	1.1 feet	0.9 Millimetres

The uppermost portion of the glomus compartment was situated ½ millimetre below surface of the nailbed.

DESCRIPTION OF THE MODEL

The base of the model consists of a large artery running in a transverse direction and parallel to the surface of the nailbed. It then takes a right-angled bend and continues distally forming an arc with its convexity towards the surface. The distal end of the artery disappears from view where it enters the deeper tissue. (Figs. 9 and 18). This described the main vessel or parent vessel from which arterial branches and ultimately the glomus bodies arise.

The Arterial Branches

These total five in number and arise from the parent vessel. Only one branch takes origin from the concave portion of the parent vessel before the latter disappears from view. The remaining four branches come off the convex part of the main artery. Of these one arises singly while the others arise by a large trunk which divides into three smaller branches. Of the latter, the largest branch continues distally parallel to the surface of the nail-bed. In its proximal half it gives off no glomus bodies whereas from the distal half, which is considerably narrower, two glomus bodies arise.

The Glomus Bodies

In all, 10 Glomus bodies were encountered.

Glomus bodies 1,2,3,4,5,6 and 7 were fully reconstructed whereas 8, 9 and 10 show only reconstruction

of the venous extremity. In 9 and 10 the artery of origin was situated outside the microscopic field and in 8 the artery could not be followed due to tissue damage.

Each glomus body consists of the following structures:-

(a) Afferent Arteriole

This arises from the smaller arterial branches at a point where the outside diameter of vessel narrows to approximately 1 - 1½ inches or in situ 80 - 120 microns. In the majority of the glomus bodies, the afferent arteriole was difficult to demonstrate on account of its shortness and the fact that it was often obscured by the anastomotic coils. Glomus 3, in the model, shows this afferent arteriole clearly. These arterioles come off the arterial branches at right angles except in the case of Glomus 3 where it is a continuation of the branch. (Figs. 20 and 21).

(b) The Anastomotic Vessel (Figs 9, 24 and 25)

These are thickwalled, tortuous vessels slightly larger than the afferent arteriole. The majority run parallel to the surface to join the veins. In 1 and 6, the channels are of simpler form, run a straight course, and can be seen linking up with the veins at one point. In 3, 5 and 7 their structure is much more complex. The vessels run a very tortuous course and in some situations

are closely adherent to the arterial branches. They do not terminate in a single portion but have multiple extremities linking up with different veins.

(c) The Veins

The collecting veins are small tortuous channels which link up and drain into large venous sinuses. These, in turn, drain into large veins which accompany the artery. By means of communicating vessels the large veins on either side of the artery are joined.

The rich venous drainage of the efferent side of the anastomotic channel is clearly shown. It is interesting on account of its diffusion over a large area and demonstrates how one glomus body serves a large surface area.

THE PREGLOMIC ARTERY

The origin of this vessel from the afferent artery could not be found. In fig 9 an arteriole which passes through glomus 5 may correspond with the preglomic artery described by Popoff. (1934).

The Nerves

Special nerve-stains were not used therefore only large nerve trunks were observed. A large nerve commences proximally, courses over surface of artery where it gives off a large branch. This branch runs alongside the parent

artery where it divides into a supeficial and deep portion. The latter had only been followed for a short distance. The superficial portion continues distally, crosses the large arterial branch near its origin and divides into three small nerves. One of these runs on the surface of the arterial branch. Another large nerve, in the form of a sheet, runs transversely underneath the aforementioned artery. It gives off no branches in the model.

THE INFORMATION OBTAINED FROM THIS RECONSTRUCTION:-

1. The presence of a large number of arteriovenous anastomoses in normal tissues of the fingers was confirmed. Their origin from a small artery, their complicated structure and junction with the venous system was clearly demonstrated.

2. A three-dimensional picture of the glomus body was produced. Previously only schematic reconstructions of the glomus bodies were demonstrated by different authors. (Figs. 10 and 11).

3. The relation of the glomus body to arteries, veins and nerves, were clearly shown.

4. The collecting veins have the shape of a broad ruffle or cape which encircles the glomus and forms a voluminous receptaculum. (Fig. 25). The importance of this feature in the temperature control of the body will be discussed under The Physiology.

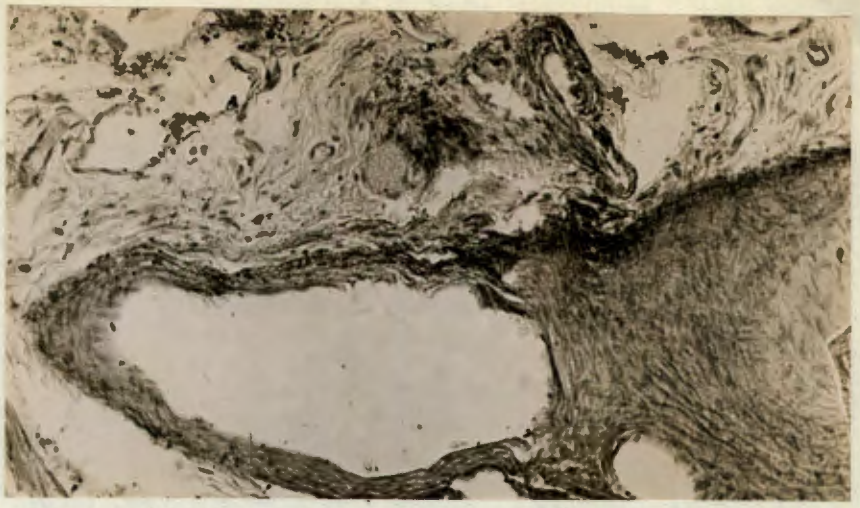
5. The glomus bodies occur in compartments and are

congregated around the parent artery. (Fig 9). In the immediate vicinity of this vessel, no glomus bodies could be found. This fact is important when these bodies are enumerated in the skin. The marked discrepency in the number of Glomus Bodies per centimetre of tissue may be due to their uneven distribution in the tissues.

6. The close relationship of glomus bodies and nerves were clearly shown. This is best demonstrated in Glomus 5 (Fig. 9) where the efferent portion of the glomus body is seen to approximate a nerve very closely. This brings out an interesting point in the production of pain in glomus tumours and demonstrates how readily the nerves can become incorporated during overgrowth of one of these bodies.

7. The importance of serial sections in the study of histology is readily appreciated and is best illustrated in Sections 69 - 74 of Glomus 7. From Slide 69 (Fig. 23) one gains the impression that this glomus is a simple structure and arises from terminal part of arterial branch. When reconstructed however, the complicated nature of the arterial branch beyond the glomus can be demonstrated. In Slide 73 (Fig. 22) the presence of muscle cells does not represent a transition of muscle to glomus cells but is due to a section taken through both arterial wall and glomus body where the latter is adherent to the vessel. This has been confirmed by several serial sections.

8. An interesting point has arisen in connection with the origin of an artery. On following serial sections 83 to 97 its presence in the wall of the main artery can be discerned. (Figs 14 and 15). It therefore has traversed the arterial wall for 15 sections or 150 microns before branching off, unlike the other arteries in this model. It reminded one of the passage of the ureter through the bladder wall. Contraction of the parent vessel will, at the same time, shut off the blood flow to its tributary. This feature, if present in other vessels in the body, can present some interesting points in the control of the circulation.



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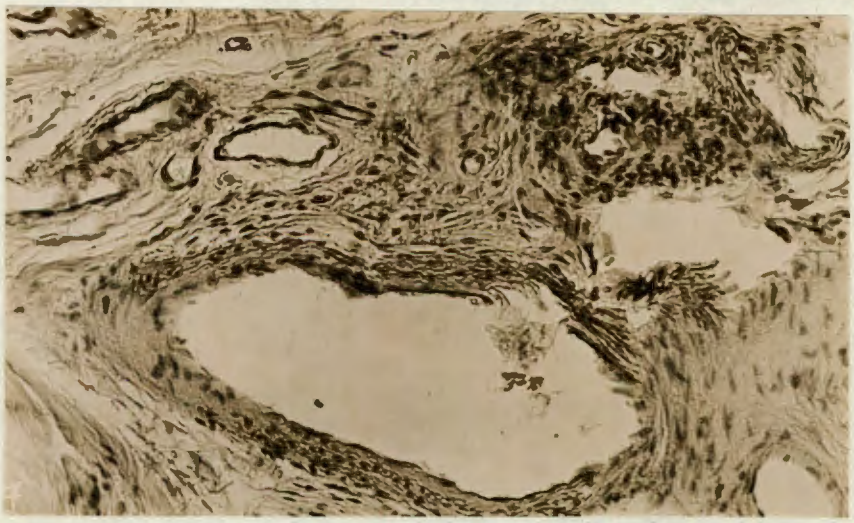
88



87

FIG. 14 H & E X 150

Serial Sections 89-84 showing origin and termination of Glomus 1.

(Continued on next page)

86

85

84

FIG. 15 H & E X 150

Glomus arises from lateral side of artery in Slide 89 and continues in a coiled manner until it ends in a vein in Slide 84. Throughout series in bottom right hand corner, the origin of an artery passes through all sections. This feature is comparable with passage of ureter through bladder wall.

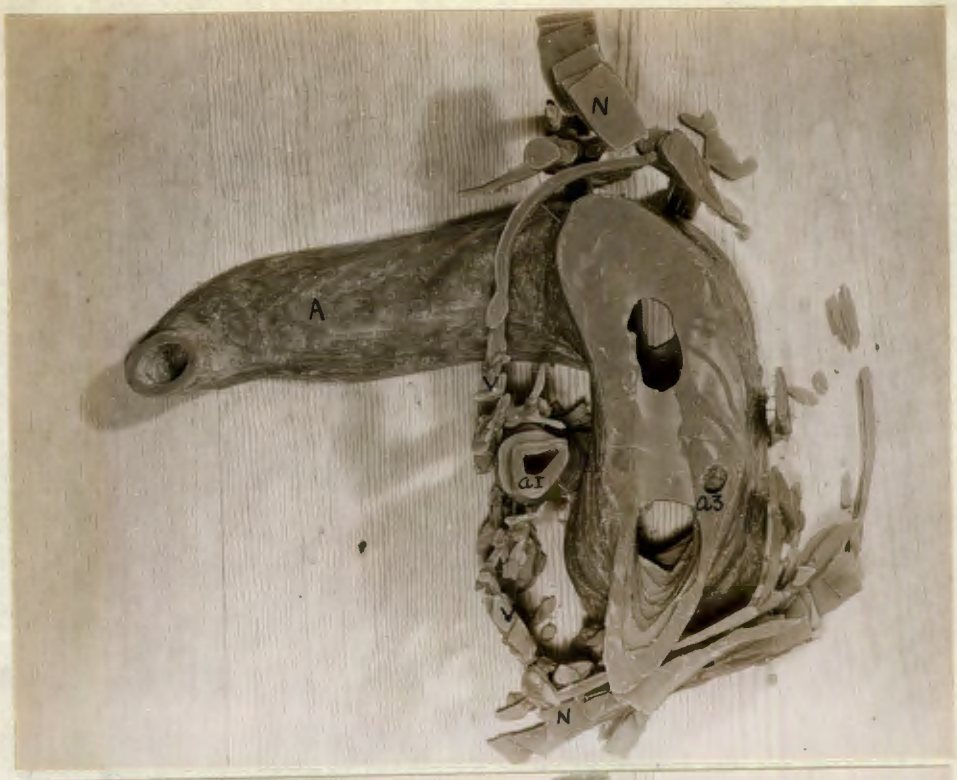


Fig.16

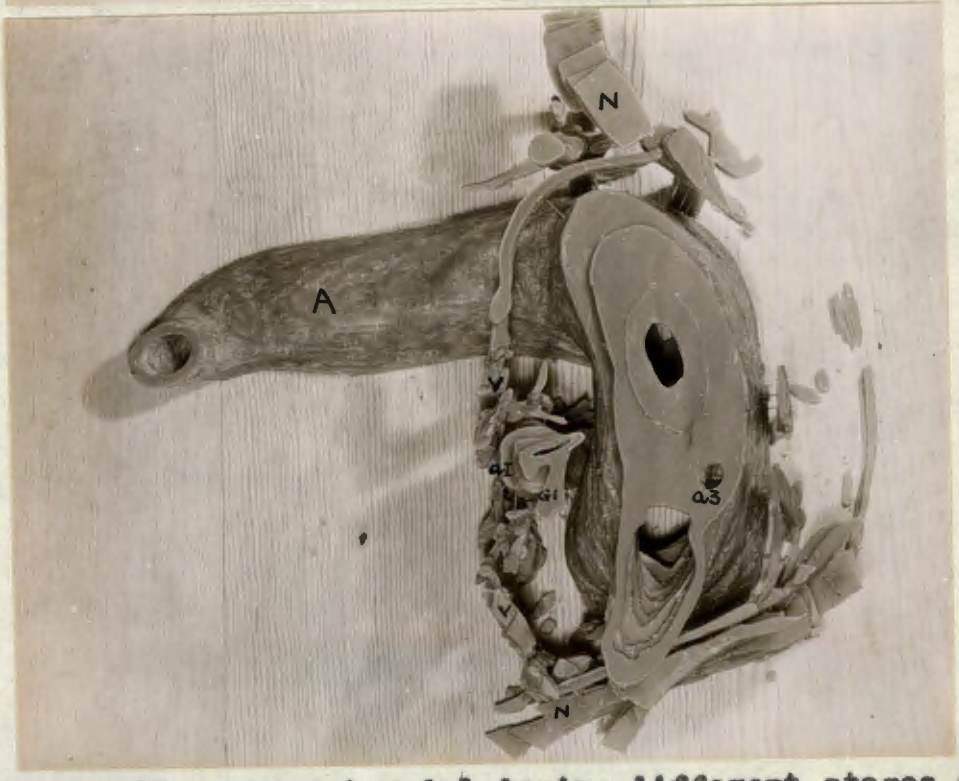


Fig. 17

Figs. 16 and 17 represent model during different stages of reconstruction up to sections 90 and 89 respectively. Note the commencement of Glomus 1 (Gl) in Fig. 17.

A. Main Artery
V. Veins
Gl. Glomus 1
N. Nerve

Fig. 18

Glomus 1 has been completed and glomus bodies 3,4 and 10 are commencing.

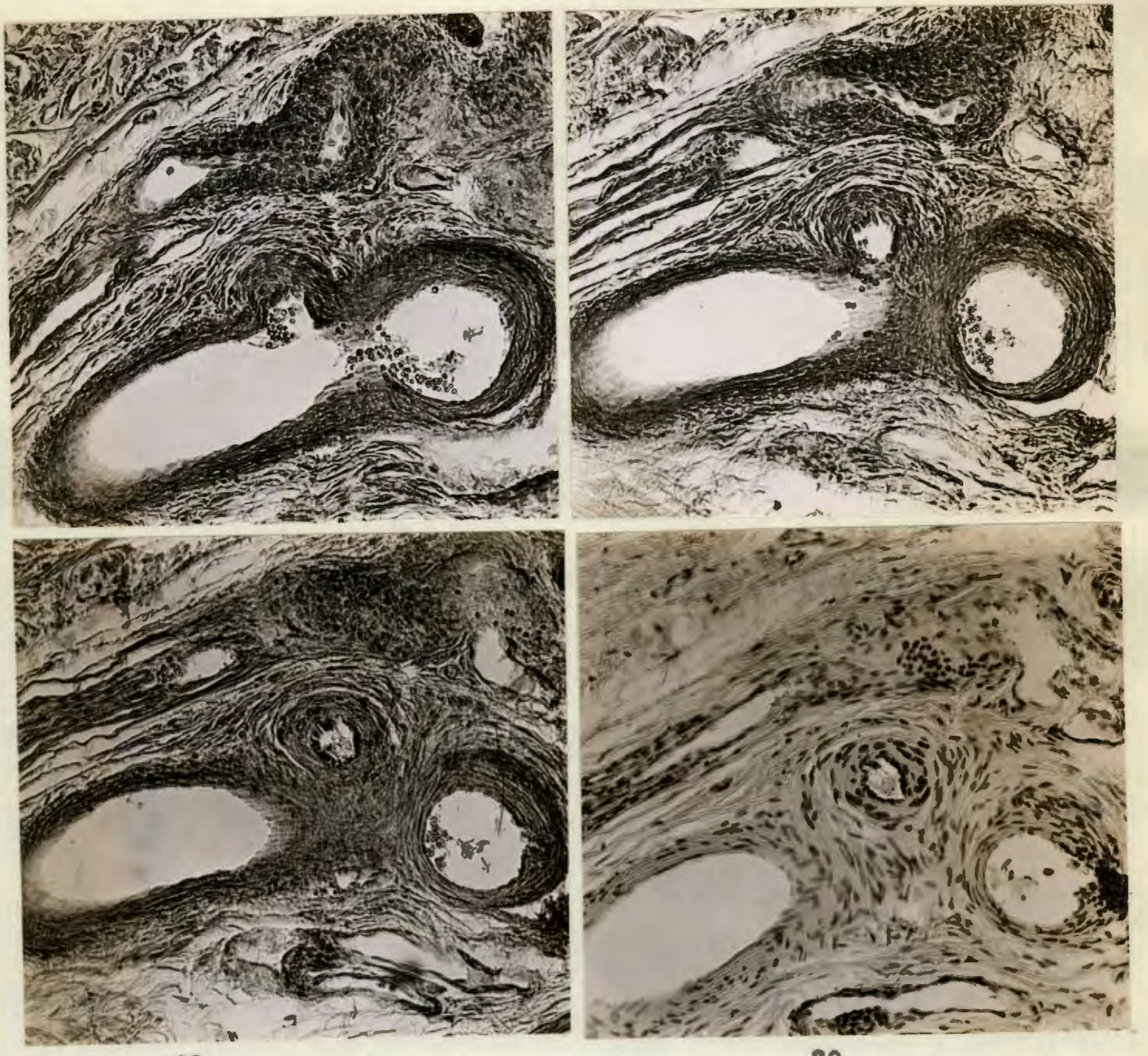
A.....Main Artery
V.....Veins
G.....Glomus
N.....Nerve
a.....Arterial Branches.

Fig. 19

Glomus 1 enlarged. Note thick tortuous channel with narrow lumen coming off Artery a 1.

83

82



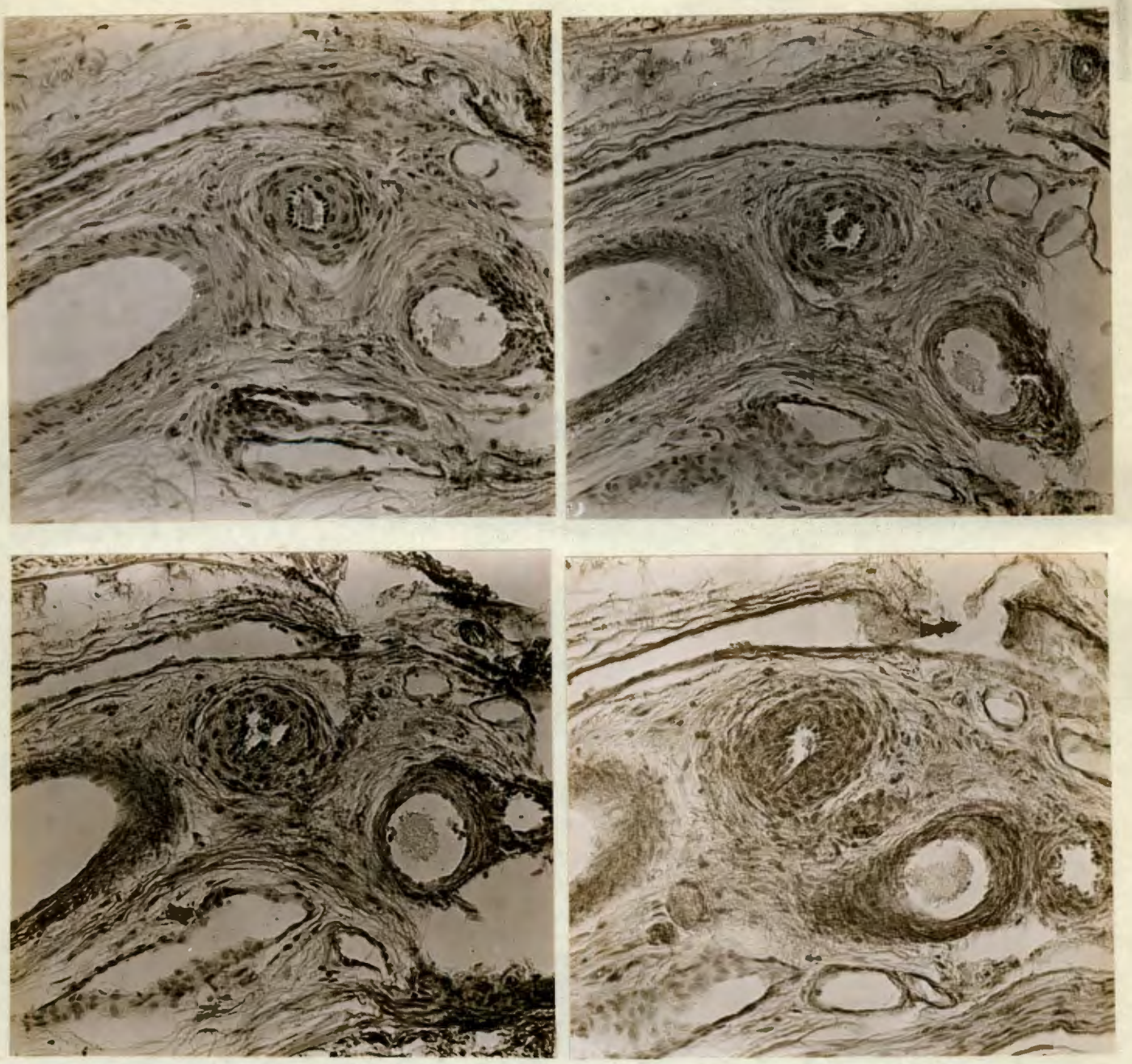
81

80

FIG. 20 CARMINE & H & E X 95

Slides 83-76 showing origin and development of Glomus 3. It arises from terminal portion of arteriole. In 83 afferent arteriole is shown coming off artery. 82 and 81 show rounded lumen of arteriole and presence of muscle cells in the wall. In 80 another glomus is commencing from artery on right of picture.

79 78



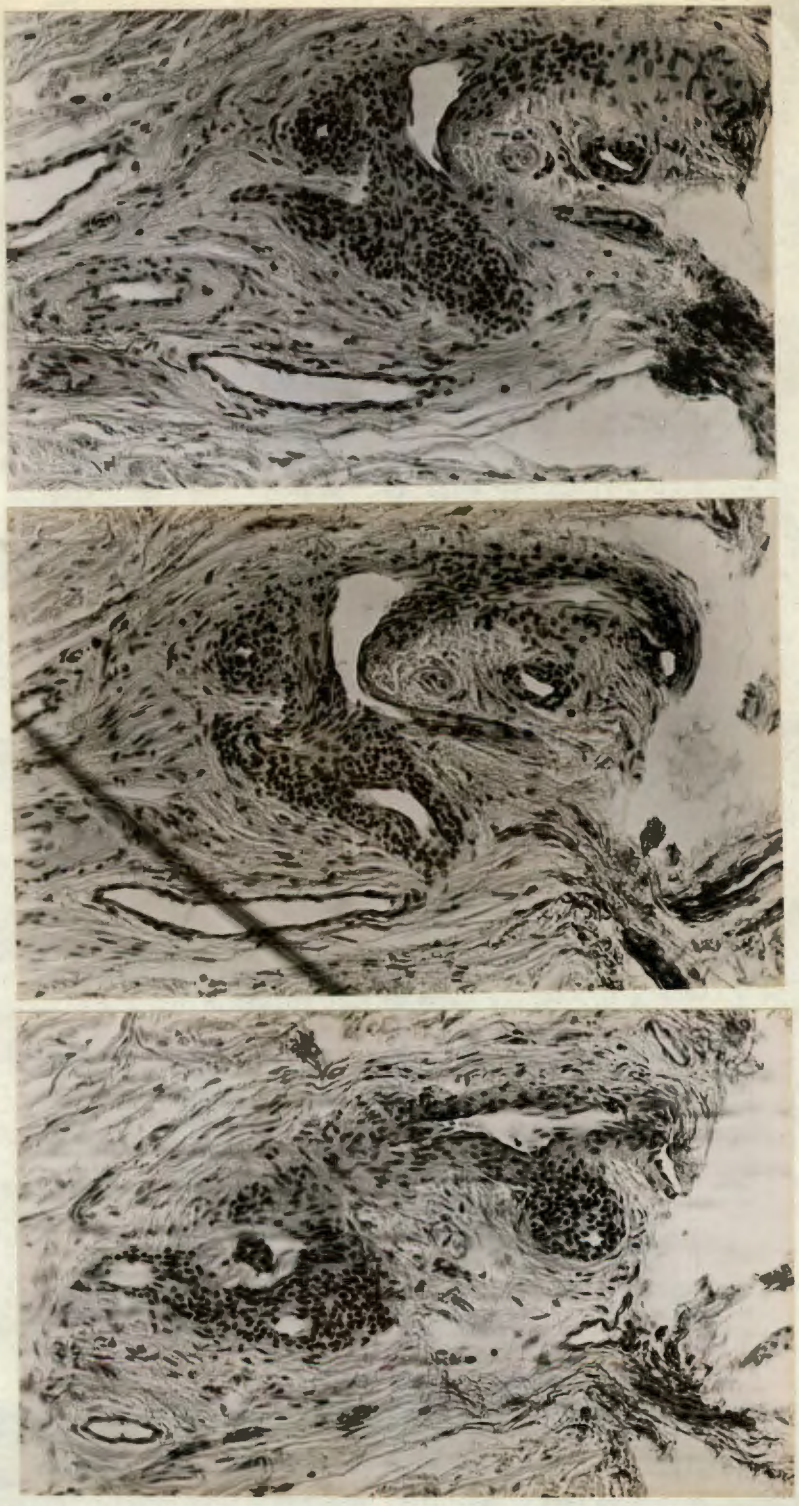
77 76

FIG. 21 CARMINE & H & E X95

Series Continued

78 Wall of arteriole is thickened and evidence of glomus cells
Lumen of vessel irregular due to endothelial elevations.

76 Shows complete transformation of muscle to glomus cells.
NOTE large nerve in lower right hand corner.



74

73

72

FIG. 22 H & E X 150

Serial Sections 74 - 69 showing Glomus 7

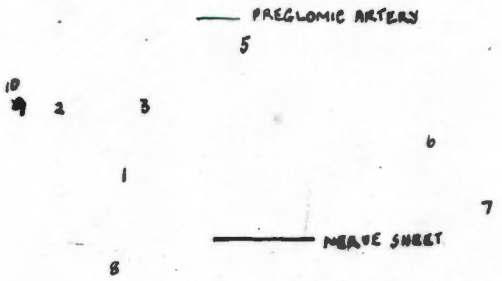
H & E X 150

(Continued next page)

FIG.23 H & E X 150

This is a very complicated glomus possessing multiple terminations. During reconstruction, it is shown to be more complex than depicted above. The coils closely embrace the artery of origin and in slide 73 the section has been cut through both artery and glomus. The link up with a vein is well demonstrated in slide 69. The continuation of artery can be seen in Slide 74.

H & E X 150.



3

9

GLOMUS I

Fig. 24

Colour photograph (side view) showing glomus bodies 1,2,3,5,6,7,8,9 and 10. Glomus 4 is hidden from view by small tortuous veins. Note that efferent portion of Glomus 5 crosses a large nerve.

Fig. 25

Glomus 1. Photographed from above. Note the large venous cuff surrounding and linking up with this glomus. Glomus bodies 9 and 3 are also visible in picture.

E. THE REGIONAL DISTRIBUTION AND EMUNERATION OF GLOMUS BODIES IN MAN

In man they have been described most frequently on the pulps of the finger and in the nailbed. In the latter situation their number is greatest in the distal part of the nail bed. They also occur in large numbers on the flexor surface of the second and third phalanges, and the thenar and hypothenar eminences.

They are supposed to have a similar distribution on the feet but are never found on the dorsal surfaces of hands and feet. They have never been described in the skin taken from other parts of the body. An intensive search was made for glomus bodies in the skin of leg, thigh, coccygeal region, foreskin, lips and nose. After examining several sections of each group I was unable to demonstrate them in the above areas.

Arterio-venous anastomoses have been described in other situations and include the following:-

Intestinal mucosa, submaxillary salivary glands, kidneys, helicine arteries of the penis, gravid uterus, dura mater and coccygeal body.

The number of Glomus Bodies per square centimetre of tissue.

Grant & Bland

Index Finger

Nailbed	501
Tip	236
Flexor surface 3rd phalanx	150
Flexor Surface 2nd Phalanx	236
Flexor Surface 1st Phalanx	93
Thenar eminence	113
Hypothenar eminence	96

Second Toe

Nailbed	593
Pad	293
Sole of Foot	197

Popoff

Thumb and Great Toe (at 20 years)

Ventral surface	18
Lateral surface	10
Nailbed	24
Matrix	12

The marked discrepency in the numbers of glomus bodies per square centimetre given by above authors can be attributed to the following factors:-

1. In the reconstruction of glomus bodies from the nailbed it was pointed out that they occurred in compartments which were most numerous in the distal part of the nailbed. Consequently, the numbers will depend on area of tissue selected under the microscope.

2. As result of the tortuous course of the anastomotic canal as shown in the model, sectioning of the glomus coils at right angles to their long axis, will present as several glomus bodies.

3. The sweat glands can easily be mistaken for glomus bodies. (Fig. 7). They occur in the same layer of the skin and can be differentiated by their rounded lumen bordered by cubical epithelial cells placed on a well-demarcated basement membrane.

Grant's figures of 593 in the nailbed is not compatible with the normal. He must have counted the same glomus several times as sweat glands do not occur in the nailbed. Popoff's figure of 24 approximates the normal.

No attempt was made to enumerate the glomus bodies as it would have meant reconstructing each individual glomus in one cubic centimetre of tissue, in order to obtain an accurate result.

The volume of tissue used for reconstruction purposes measured 3 X 1.3 X 0.9 cubic millimetres and 10 glomus bodies were demonstrated in the model.

F. COMPARATIVE ANATOMY

Arterio-venous anastomoses occur not only in man but also in birds and mammals. Reptiles which are cold-blooded animals, do not possess these structures.

In birds, the arterio-venous anastomoses are found in the central parts of the webs of the ostrich, hen and duck (Clara 1927 and Grant 1931).

In mammals, they are found in the following situations:-

Nose of cat and dog

Tongue of dog

Ears of rabbits, cats and dogs (Hyrtl & Hoyer 1877)

Intestines of pig, horse, deer, cat and dog.

Ovary of deer and dog.

Wings of bats (Grosser 1902)

Hoof of pig.

Feet of cats

Tails of cats and dogs.

Uterus Gravid uterus of Hedgehog. (Goetz 1936)

G. GLOMUS BODIES IN DIFFERENT AGE GROUPS

A great deal of controversy has arisen whether

these bodies exist during foetal life.

Popoff (1934) mentions that the glomus system is absent in the foetus and that development takes place within the first few months of post-natal life. Therefore, the regulation of heat is one of the least developed functions of the premature infants.

Grosser (1902) also holds the above views.

Masson (1937) after thorough search, refutes above statement. He states that the glomus bodies owing to the thickness of their walls and presence of epithelioid cells, can be recognised during foetal life. In the 4th month they are found in the nail bed and in 5th month in the digital pulp. Their nervous structures, however, are not fully developed.

A reasonable assumption can be made that these bodies exist in foetal life but in a nonfunctioning and under-developed state comparable with some glomeruli in any normal kidney. The difficulty in demonstrating the presence of glomus bodies in the foetus, is probably responsible for these diverse views.

Most authors are in agreement that they are most abundant during adulthood. In advanced senility, the glomus units undergo atrophy and their number decreases.

H. THE NATURE AND ORIGIN OF THE GLOMUS CELL

Many views have been expressed concerning the origin of the glomus cell. Masson's contention is that they are modified smooth muscle cells which do not possess fibrils. His views are supported by the presence of intermediate types of cells which possess the characters of both muscle and glomus cells.

Krompecher (1932) states that the epithelioid cells were angioblasts and not myoblasts.

Murray & Stout (1942) performed interesting experiments on tissue cultures of the glomus tumour. They found that the glomus cells take on a different appearance and become discrete, their cell body not voluminous and have many ramifying processes. The glomus tumour gradually dissolves and within a week forms a reticular zone which extends beyond the capsule of the tumour. This reticular zone is composed of "pericytes" into which capillary beds grow. They become adherent to the capillaries and form several layers, and can be recognised by their branching shape, dark-staining nucleus with one or two nucleoli and rich chromattin. The cells do not behave like macrophages but are of the nature of vascular sattelites. No fibrils were found in sections of the cultures.

Zimmerman (1923) stated the following:-

"In vertebrates, the blood capillaries are wrapped around by special kind of cells which passes over gradually into smooth muscle fibres towards both venous and arterial end."

The cells possess compact rounded nucleus with a variable amount of cytoplasm from which extend branching processes which embrace the capillaries. To this cell he gave the name pericyte. The marked resemblance between Zimmerman's pericyte and that of the tissueculture was demonstrated by Murray and Stout.

As "pericytes" can occur anywhere on the body, one can deduce that glomus cells and tumours may occur similarly. The above findings may therefore explain the unusual situations in which glomus tumours occur in parts of the body where glomus bodies have never been found.

Fig. 26

Diagram of normal glomus bodies.

I. PHYSIOLOGY OF THE ARTERIO-VENOUS ANASTOMOSES

The subject of arterio-venous anastomoses offers a great deal of scope for physiological research. That these structures have been badly neglected by physiologists and are not mentioned in any text books of physiology, is well-known.

Clark (1938) in his review on this subject, makes the following comment:-

> "Regarding the function of arteriovenous anastomosis, the most one can say definitely is that, when dilated, they permit a large amount of blood to pass from artery to vein without passing through the capillaries. They play undoubtedly a part in the surface heating or cooling of the blood in human hand, forearm and in the rabbit's ears."

The physiology of arterio-venous anastomosis is governed by two important anatomical factors:-

1. <u>The Site of the anastomotic channel which is proximal to the capillary bed</u>. (Fig. 26)

This allows the blood to be diverted from the arterial bed via the anastomosis to the veins.

2. The structure of the anastomotic vessel:

In the wall of the canal are found specific cells, glomus or epithelioid cells which have the power of suddenly increasing or diminishing in size at different times. By this action they have the power to obliterate the vessel completely or cause wide dilation of the lumen, unlike that seen in an artery. The absence of elastic tissue in its wall further enhances this action. By virtue of this property blood is allowed to flow either to the capillary bed or directed away from it. When the anastomosis dilates its larger diameter which is 20 - 70 microns compared with 10 - 15 microns in the capillaries, offers a lower resistance. Thus the blood tends to flow through the anastomosis instead of the capillary bed. This flow is further aided by the higher pressure in the arterioles than in the venules.

A very large volume of blood can traverse this canal. In order to appreciate this point, we have to consider the principle involved in Poiseuille's law, which reads as follows:-

> "The amount of flow from a constant pressure source varies with the 4th power of the diameter"

Thus through a vessel with an inside diameter of 50 microns 625 times more blood will pass in the same time

than through one with a diameter of 10 microns. When the large number of vascular fistulae in the body are taken into account one realises how large a volume of blood can be shortcircuited by them.

EXPERIMENTAL PHYSIOLOGY

In experiments performed by Goetz (1940) he showed the action of arterio-venous anastomoses in the ear of the rabbit. The external carotid artery and external jugular vein of the rabbit was dissected out. All their branches were tied except those branches to and from the ear. Flanged cannulas were inserted into them to record the arterial and venous blood pressures. (Figs. 27 and 28).

From these records it was evident that a fall in arterial pressure coincided with a rise in venous pressure. Arterial pulsation was also visible in the veins. At the same time a plethysmogram of the same ear was recorded and showed a diminution in blood volume. From this he concluded that the blood was not flowing through the capillary bed, but was shortcircuited via the arterio-venous anastomosis.

In other experiments the same author tried the effect of cold on the rabbit's ear. (Fig. 29). By measuring continuously the oxygen contents of the jugular vein by photo-electric methods he demonstrated

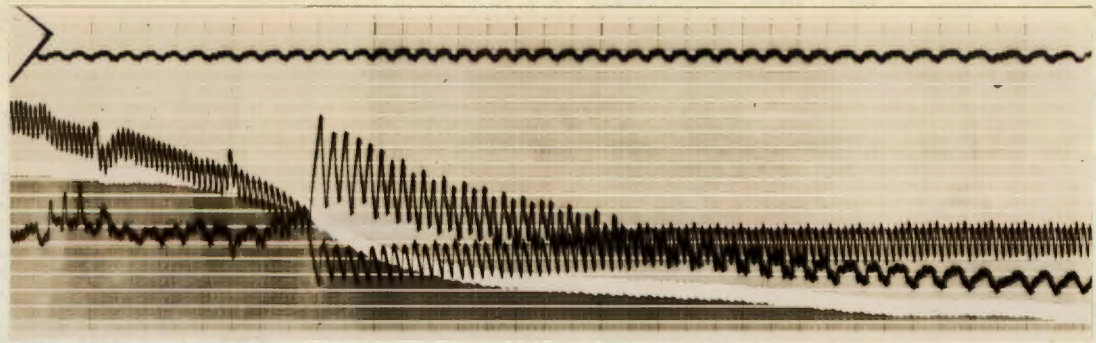


Fig.27

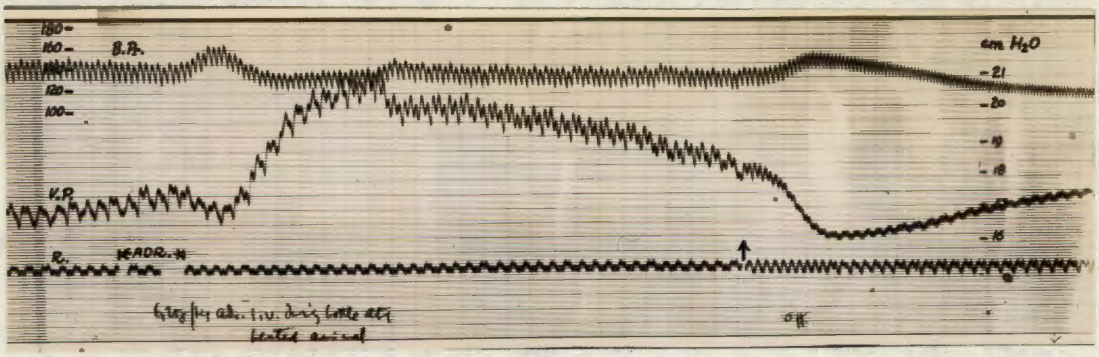


Fig. 28

Figs.27 & 28 are recordings of arterial and venous pressures of arteriovenous anastomoses of a rabbit's ear.

Note the fall in arterial pressure coinciding with a rise in venous pressure and occurrance of arterial pulsations in the veins.

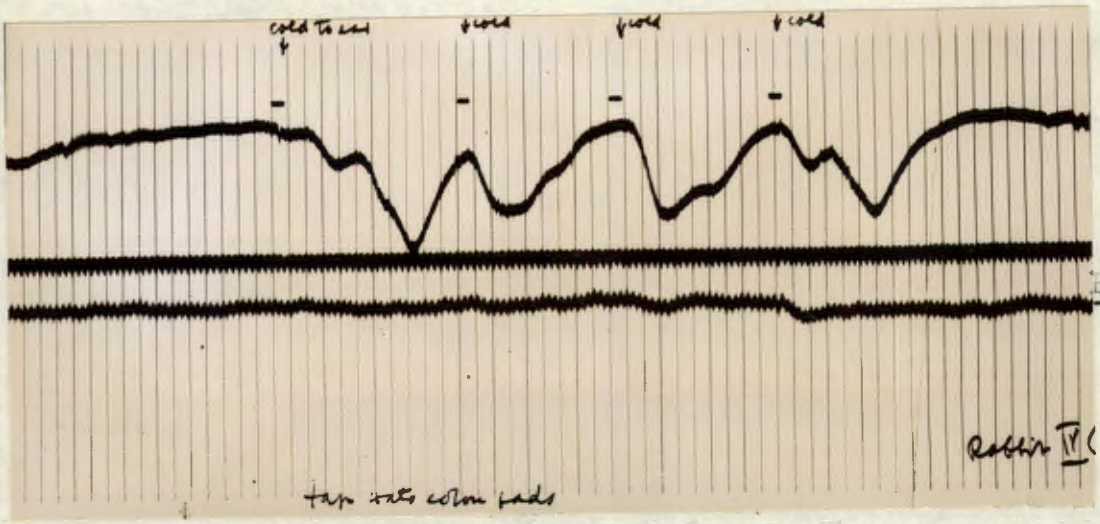


Fig. 29

The effect of cold on the arteriovenous anastomoses of rabbit's ear.
Note the fall in oxygen content of venous blood directly when cold is applied to the ear.

that the application of cold instantly produced a fall in the oxygen content. The fall of oxygen in the venous blood was attributed to the closure of the arteriovenous anastomosis. This resultedin the blood flowing via the capillaries where the oxygen was used by the tissues.

From the above experiments he concluded the following:-

1. A fall in arterial blood pressure may occur when the anastomosis dilates.

2. A rise in venous pressure will be traced.

3. An increase in rate of flow through the veins will be recorded.

4. A decrease in the volume of the capillary bed will result.

5. Pulsation in the veins synchronous with the arterial pulsation occurs.

6. Arterialisation i.e. rise in oxygen content of the venous blood will result.

7. By regulating the amount of blood flow through the capillary bed the arterio-venous anastomosis

indirectly serves to control the body temperature.

Other workers have performed experimental work on the arterio-venous anastomoses of animals and man.

Clark(1938) by means of specially constructed windows placed in the rabbits ears, was able to study the behaviour of the arterio-venous anastomoses in vivo. He made the following observations:-

A. The Arteries and Arterioles

1. The arteries and arterioles undergo periodic contractions at different rates. This irregular contraction causes a variation of amount of blood-flow through the anastomoses. It may also result in a reversal of the blood-flow from veins to arteries.

2. When the rabbit is disturbed, the arteries and arterioles contract.

3. Moderate cooling of the ear causes contraction, while moderate heating results in dilatation of these vessels.

B. The Anastomotic Channel

They behave much in the same way as the

arteries with these differences:-

1. They have a great tendency towards independent action.

2. They contract more speedily. Thus the lumen of an arterio-venous anastomosis 20 microns in diameter is obliterated in ½ second while an arteriole of same size takes 1½ seconds. He compared its rapid action with that of a stop-cock.

3. They have a wider response to local heating.

4. Near areas of infection, they remain widely open.

5. When the nerves to the ear are injured, they remain dilated for 10 - 14 days after which the muscle tone recovers and artery rema ins at a narrow caliber.

6. New channels form from others when the ear is subjected to trauma or infection.

Grant (1931) by means of a binocular microscope has studied the circulation in the rabbits ears in relation to temperature changes. He found that when cooled below 10°C. the arterioles contract mementarily but within one or two minutes open up. Despite the

dilatation of the arteries and arterioles, the circulation in these vessels and in their capillaries remains sluggish. The blood-flow through the anastomoses, however, is markedly increased.

Grant concluded that the arterio-venous anastomoses may be regarded as shunts to allow an increase of blood-flow through the ears to prevent the temperature from falling too low. The capillary circulation remained sluggish on account of the decreased metabolism of the cooled tissues.

In rabbits, the anastomoses in ears served the function of maintaining both local and general body temperature.

Grant and Bland (1931) carried out experiments on the human fingers and noted the local temperature reaction when exposed to cold. He immersed the fingers into iced water and noted the temperature reactions of skin of these fingers by means of thermo-couples. At first the temperature of the fingers dropped but after a few minutes would rise two degrees above that of the iced water. The tip of the finger responded more markedly than the remaining portion. This rise in temperature they attributed to the action of the glomus bodies in the finger.

One cannot accept their conclusions without a certain amount of restraint as they have not excluded the paralysing action of cold on the capillaries being responsible for this rise in temperature. In Grant's

experiments on rabbits' ears, he was able to observe the behaviour of the anastomoses and the capillaries through a microscope. This was not carried out in the case of the human fingers.

By experiments on birds' feet Grant and Bland found that by immersion of one foot in crushed ice, there was a rise in temperature compared with the other foot. According to these authors the prolonged contact of Birds' feet with frozen surfaces during winter is made possible by this physiological factor. This still does not exclude the possibility that increased temperature reaction is not due to vasodilatation of the capillaries.

Lewis and Pickering (1931) have shown that the tips of fingers are coldest when the body as a whole is cold but warms most rapidly because of opening of arterio-venous anastomoses. These experiments are not conclusive.

Lewis states that the reactive hyperaemia occurring in a limb after release of a Tourniquet is most marked in the finger tip as shown by the greatest rise in temperature. According to him it is due to the action of the glomus bodies without having first excluded the part played by the capillaries.

The Function of the Anastomoses in man

1. The Arteriovenous Anastomoses play an important

part in the nutrition of the tissue since they may direct the blood to or from the capillary bed.All the sequelae resulting from interference of blood supply to the tissues namely fibrosis, partial or total destruction will therefore depend on the volume of blood passing through the fistulae.

2. In the Kidney

(a) In certain organs, like the kidney, where the anastomoses are very numerous and where a large blood supply is necessary for normal action, obliteration of these fistulae lead to marked interference of function of the organ.

(b) In the kidney under normal conditions, only a small proportion of the large number of glomeruli function at one time. No blood will flow through these non-functioning glomeruli as it has been claimed that the arterio-venous anastomoses short-circuit the blood between the arteria and vena interlobularis. This mechanism is therefore of great physiological significance as the force of the heart-beats will not be dissipated in attempting to send blood through non-functioning glomeruli. Normal functioning fistulae in the kidney will thus relieve the heart from this extra burden.

(c) The kidney being an actively functioning organ needs a high oxygen content. The oxygen-level in

the blood of the kidney is maintained through the intermediary of the anastomotic channels.

(d) The blood flow through the kidney is known not to be affected by changes in general blood pressure and it is quite possible that arterio-venous anastomoses take part in the regulation of the blood flow through the kidneys at a constant level.

3. In the Intestines

In these organs the fistulae are widely patent during starvation but close during digestive phase in order to allow a large blood volume to enter the capillaries.

4. In the Pregnant Uterus

The role played by arterio-venous anastomoses during pregnancy was demonstrated by Goetz (1936) in his work on placental circulation of the pregnant Hedge-Hog. He found that the arteries in the uterus assumed the characteristics of the arterio-venous anastomoses and exhibited the typical coiled channels with glomus cells in their walls. (Fig. 30).

5. In the skin of the extremities

The hand acting as a perfect radiator of heat serves to control the body temperature. The blood flow through the capillaries in the hand varies from one c.c. during contraction to 90 c.c. during full dilatation.

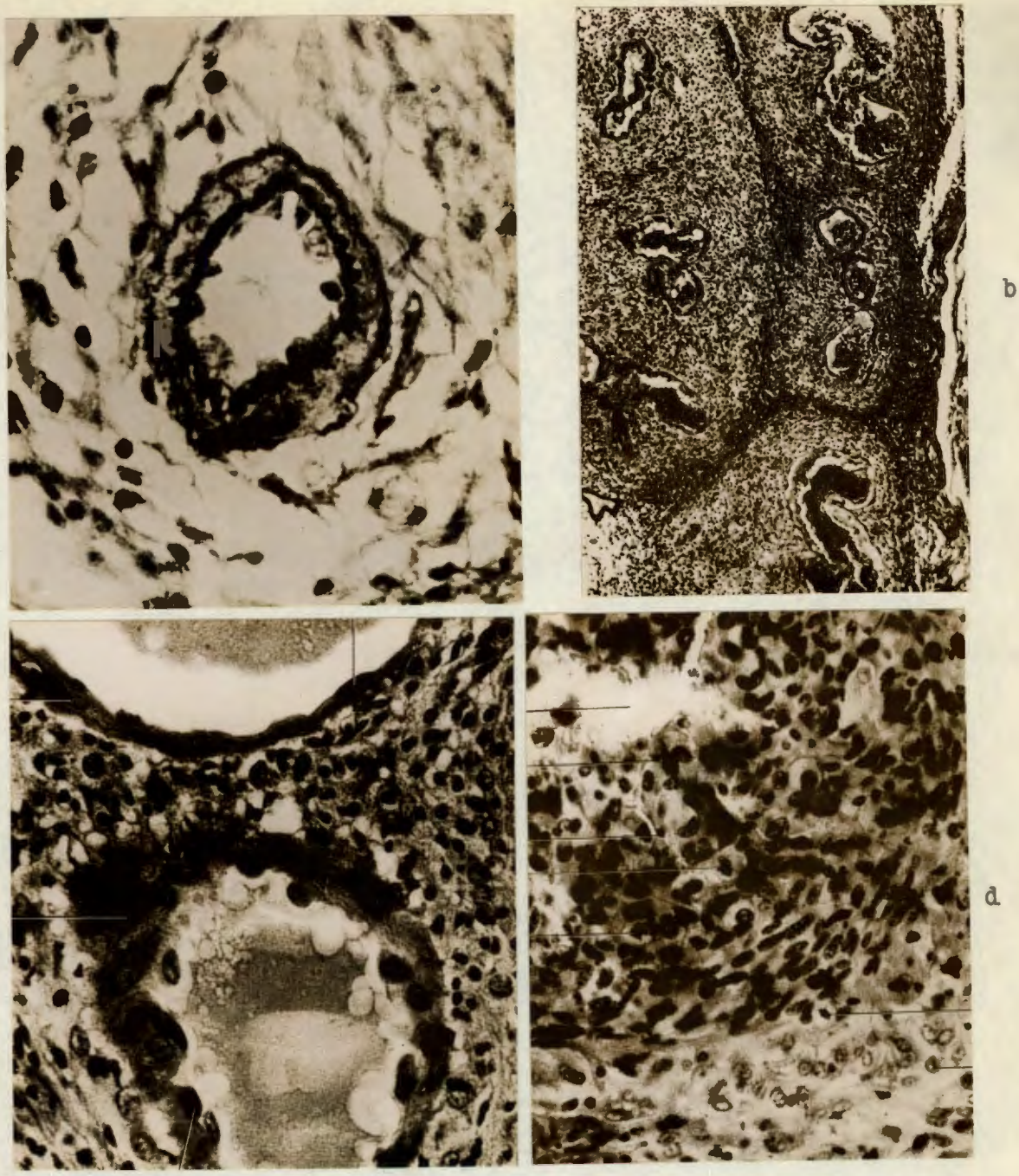


Fig. 30

Study of Placental circulation of a pregnant hedge-hog.
(Gœtz 1936)

a. Artery in muscular coat of uterus.
b. Anastomotic canal of same artery.
c. Transverse section of afferent portion of anastomotic canal showing modified muscle cells.
d. Typical thickwalled canal with epithelioid cells.

This is brought about by through the intervention of the arterio-venous anastomosis. It cannot be a mere coincidence that the glomus bodies are most prevalent in the hands and feet and are absent elsewhere in the body. The suggestion, therefore, that they function in connection with heat regulations of the body seems logical. Further support is provided for this suggestion by the fact that glomus bodies are found in large numbers in the skin of the rabbits' ears, which are known to be the chief organs of heat regulation in these animals.

The glomus bodies in man therefore serve (a) the maintenance of local temperature and (b) the regulation of the general body temperature.

One can readily understand how the local temperature is maintained when studying the glomus bodies in the model. The efferent portion of the anastomotic channel is seen to link up with veins which are spread over wide surface area. Consequently local temperatures can be maintained through the action of these channels which allows varying amounts of blood to pass under different external conditions. The general body heat can be maintained or lost in a similar manner through the intervention of these bodies. It is interesting to note here that in premature babies who are very susceptible to changes of temperature, the presence of glomus bodies are difficult to demonstrate.

In reptiles, which are poikilothermal animals in which the body temperature varies with the surrounding temperature, arterio-venous anastomoses have never been described.

How far the arterio-venous anastomoses are responsible for the regulation of the blood pressure cannot be stated with certainty. We all know, that certain types of hypertension even though they fulfil the necessary criteria for operation fail to respond to splanchnicectomy. Another factor apart from nervous control, has been looked for by various workers to explain this finding. The participation of these arterio-venous anastomoses in the genesis of hypertension should be kept in mind and the involvement of their structures should be excluded.

Popoff (1934) has described the appearance of the glomus bodies in senile arteriosclerosis and found the afferent arterioles and anastomotic channels widely patent. This would explain the interference of blood supply to a toe and the presence of gangrene in some cases caused as result of diversion of blood from the capillary bed.

Lastly the effect of arterio-venous anastomoses on the venous return to the heart has not been well investigated.

Whether they can act as small pumps by opening and closing and thus propelling the blood to the heart has still to be proved.

PART II

A. HISTORICAL REVIEW OF GLOMUS TUMOURS

We owe a great deal of our present knowledge of the Glomus Tumours to French Surgeons and Neurologists. In 1920 Barré, a French Neurologist, described a small painful subungual tumour associated with a Horner's syndrome and vasomotor changes in the affected hand. Various measures were tried without relief, including alcohol nerve injections and even division of the digital nerves. On removal of this small bluish tumour, the patient had complete relief of symptoms.

In 1922 Barré published three more cases, two of which he gave to P.Masson for study. The last investigator, a Professor at Strasbourg University, had already another similar tumour which he had obtained in 1916. He was struck by the fact that all three tumours had the same morphology and that all the patients had suffered from paroxysms.of pain. All the tumours were made up of a tangible mass of well-developed arterioles, some with smooth muscle in their walls, all of which had peculiar epithelioid cells arranged about their lumina. All these tumours had large corpuscles of Vater-Pacini compressed and flattened out against their capsules and these Masson felt must have been responsible for the pain.

Believing that such a growth must represent the hypertrophy of some sort of organ, because of its orderly arrangement and rich nervous connections, he examined

serial sections of fingers and came upon peculiar arterio-venous anastomoses resembling the structure of the tumours. These were found everywhere in the deeper layers of the skin of the fingers.

Somewhat similar structures had been described by Ruffini, but without the details noted by Masson, who could not be sure, therefore, that they were the same.

Since this structure consisted of a conglomeration of vessels and resembled the glomus coccygeum, he named it a cutaneous glomus. On account of its rich nerve supply, he gave it the descriptive name of neuromyo-arterial glomus. Masson's account, published in 1924, was recognised as accurate and has received widespread acceptance.

Martin and Dechaume published two more cases the following year and in 1927 Masson and Gery reported four cases away from the fingers and occurring in the arm and thigh.

Looking back in the literature, one finds that various painful cutaneous tumors had been described by English, German and French authors, prior to 1920 when Barre made his first reports - these tumors had been described under a variety of names, probably due to the lack of thorough histological investigations. Thus, they appear under nomenclature of angiosarcomas, peritheliomas, painful subcutaneous tubercle, angioma and false neuroma.

In reviewing the German literature, one finds that painful tumors of fingers and toes were described by various authors and labelled angiosarcomas or colloid

sarcoma (Schuh 1862). Thus, in 1877 Kolaczek reported 2 cases beneath the great toe nail. Kraske in 1880 and 1887 stressed the clinical features of these painful subungual "angiosarcomas" which he felt formed a definite clinical entity. He pointed out the lack of Metastasis and complete relief by local excision, which made classification of such tumours in the group of sarcoma somewhat doubtful.

Müller continued the series in 1901, changing the name to "Peri-thelioma Subunguale".

As late as 1927 Carstensen reported a case of angiosarcoma, apparently unaware of the abovementioned publications.

In France, Chandelux in 1882 published a paper on "Histological Research on Painful Subcutaneous Tubercles". He reported a tumor of forearm which he described as an epithelioma but which, judging from the history and histological report, resembled glomus tumors.

The term "painful subcutaneous tubercle" had been devised by William Wood of Edinburgh in 1812. His articles contain clinical descriptions of the cases which he saw, together with abstracts of others which he gathered from the literature.

Greig summarised his observations as follows:- "Wood noted its long duration, small size, its benignity, its limitation of growth, its firms consistency, its definition, and its site. But above all, he noted the

character of the pain, which was intermittent, spasmodic, subject to paroxysmal exaccerbations and often of excruciating severity.

The histology in those days was still unborn and nomenclature was founded on clinical observation. The majority of Wood's cases occurred in parts of limbs away from fingers and toes. Consequently, his cases were probably a mixture of glomus tumours and leio-myomata.

In 1829 Wood reverted to the consideration of painful subcutaneous tubercle and discovered that such tubercles had been described by many of the older writers, even back to Hipprocrates and Galen.

Several other authors, like James Paget (1870) and Duputreyn (1835) wrote about them. The term "painful subcutaneous tubercle" appears in Alexis Thomson's monograph "On neuroma and neurofibromatosis" in 1900.

Greig in 1928, under the title of "Subcutaneous Glomal Tumors (Painful Subcutaneous Nodule)" described three cases but unfortunately failed to give a lucid histological picture.

Since Masson published his description of the glomus tumor in 1924, reports of cases appeared in the literature from all over the world. The greater part of the literature still came from the Continent, particularly France & Germany.

It was not until 1935, when glomus tumors appeared in the American Literature. Until then, in eleven years,

only 58 cases had been reported. In that year A.P. Stout and O.T.Bailey gave excellent accounts of the tumour and added descriptions of cases of their own.

Radasch in November 1937 read an excellent paper on glomal tumors before the Pathological Society of Philadelphia. He stated that total number of cases reported was 90, amongst which 4 were instances of multiple tumors. The following tabulation will give an idea of number reported up to that year.

		Reported	Collected
Adair	(1934)	12 (one with 3)	-
Bailey	(1937) (1935)	7	1
Geschickter	(1936)	-	1
Burman and Gold	(1935)	2	-
Greig	(1928)	3	15
Horsley	(1936)	1	-
Jirka and Scuderi	(1936)	1	-
Love	(1935)	1	-
Lewis & Geschickter	(1935)	19	-
Raisman and Mayer	(1935)	3	10
Stout	(1935)	12	-
Radasch	(1937)	4	-

Mackey and Lendrum in the British Journal of Surgery, 1936, reported three cases of glomus tumors and described the histology in detail.

With their histogenesis established, various names have been given to the tumors. These include glomus tumor, "tumor du glomus neuromyo-arterial" and angiomyoneuroma. Bailey notes that these terms are too cumbersome. He suggests the name glomangioma, to denote an overgrowth of a specific type of arterio-venous anastomoses which forms a subdivision ofthe group of angiomas.

As far as I am aware no cases of glomus tumors have been described in the South African Medical Journal and the South African Journal of Medical Sciences.

B. THE HISTOLOGY OF THE GLOMUS TUMOURS

In general, the histological appearance of the glomus tumour bears a striking resemblance to the glomus body. It is therefore made up of three essential elements viz. nerves, glomus cells and vessels. These elements are distributed in varying proportions and in some tumours the anatomical features of the glomus bodies can be recognised. This raises the question whether these are true neoplasms or organoid hyperplasias of normal structures.

THE CAPSULE The tumour, in majority of cases, possesses a well-defined capsule (Figs. 32 and 52). Whether this represents a true capsule, has been contested by some authors. Bailey (1935) states that this is a false capsule resulting from condensation of surrounding connective tissue. The absence of a capsule in subungual tumours (Fig. 77) tends to support this view. In addition to arterioles, the capsule contains veins with thin walls. Some of these vessels show the presence of elastic tissue and can be considered as vessels of extraglomic origin.

THE TUMOUR PROPER

A. Glomus Cells. The most diagnostic histological feature of the tumour is the presence of glomus or epithelioid cells. These are polyhedral cells with large, rounded, slightly vesicular nuclei. The cell

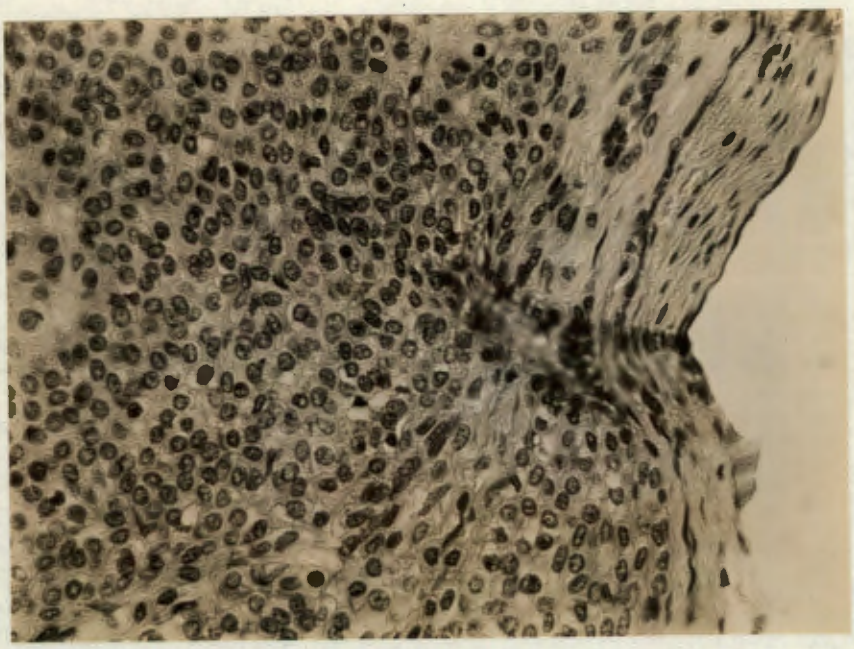


FIG.31 H & E X 440

High power of glomus tumour (case 6). Note the typical glomus cells with clear staining cytoplasm and dense rounded nuclei. The cells are closely packed with few vascular spaces (paucivascular type). The wall of afferent artery is visible on right side of picture.

boundaries are indistinct with haematoxylineosin staining but if shown up by Van Giesen's stain, appear compressed.

These cells are arranged in two ways:

(a) In closely packed cell-groups with little inter-cellular stroma and few vessels. (Fig.31).

or

(b) Loosely arranged cells placed around large vascular spaces. (Fig. 34).

These groups correspond with the paucivascular and angiomatous tumours respectively. (Masson 1937).

B. Vessels. Two types of vessels can be recognised.

1. Where the glomus cells are separated from the endothelial lining by some connective tissue and muscle.

2. Where the glomus cells rest directly on the endothelial layer. (Fig. 35).

The former shows the presence of elastic tissue in its wall and represents the afferent artery to the glomus. The latter has no elastic tissue and are coils of the anastomotic channel.

The afferent artery pierces the capsule of the glomus tumour at one pole and breaks up into numerous

FIG.32 H & E X 60

This picture shows edge of glomus tumour with a normal glomus body below and to the right, in the surrounding connective tissue (case 1)

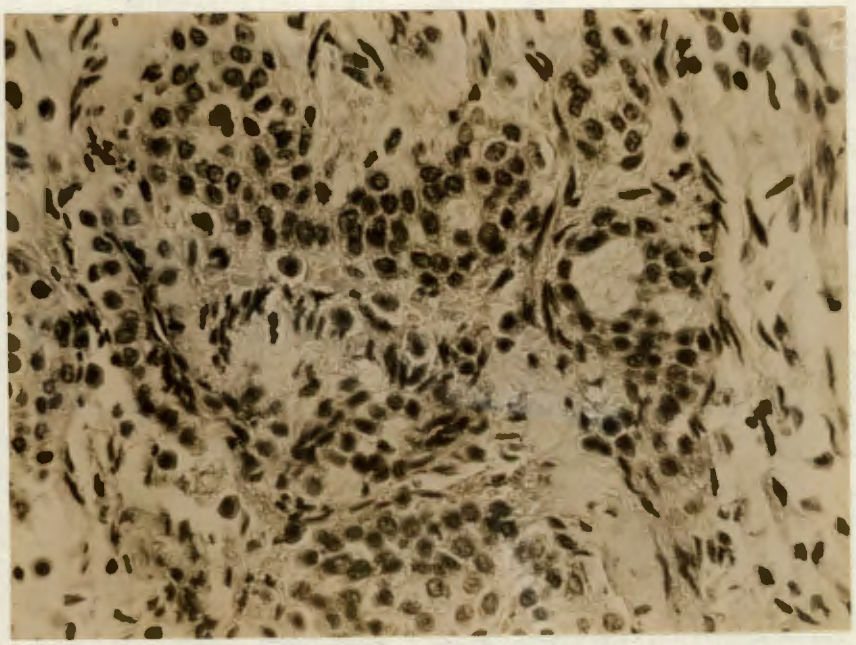


FIG. 33 H & E X 440

High power showing a glomus body in upper half of field and cells of glomus tumour below. Note similarity of the cells (Case 5)

ramifications inside the tumour. (Fig. 52).

C. Nerves. The demonstration of the nerves inside the tumour has proved extremely difficult. Many diverse views have been expressed on this subject due to errors in staining and confusing the nerves with connective tissue. Masson, who has done most of the work on this subject, has demonstrated the presence of both medullated and non-medullated nerve-endings in the tumour. The latter are closely associated with the cells and in some cases were shown to enter the glomus cells.

SURROUNDING TISSUE (Figs. 36 and 37)

Numerous large nerve bundles were found in the tissue in the immediate neighbourhood of the tumour. The presence of Pacinian corpuscles in these situations, was confirmed in some cases. The view held by Masson that these bodies were compressed or flattened could not be ascertained.

Only where the tumours arose from the hands or digits, were we able to demonstrate the presence of normal glomus bodies in neighbouring tissue. (Figs. 32 and 33).

FIG. 34 H & E X 95

Angiomatous type of glomus tumour.
Note the large number of vascular spaces.
(Case 3)

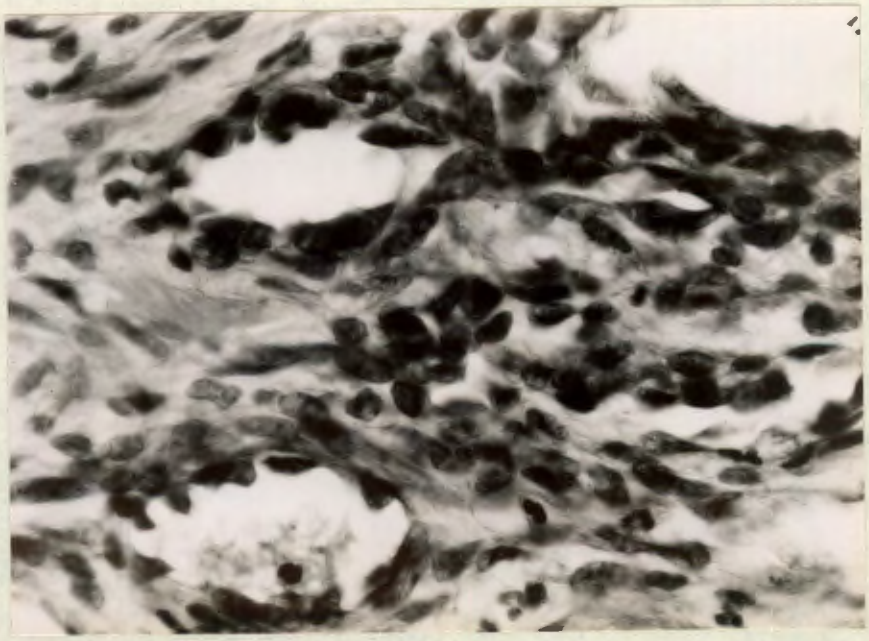


FIG. 35 H & E X 640

High power of same tumour

FIG.36 H. &. E. X 60

Two large pacinian corpuscles in transverse section showing onion-peel formation. On their right some glomus bodies are visible. The rest of field shows numerous sweat glands and some nerves.

FIG. 37 H & E X 60

The close relationship of glomus tumours to nerves is demonstrated. On the left the edge of glomus tumour is seen. Close to the capsule of the tumour, a large pacinian corpuscle (cut obliquely) is visible. A large number of nerve bundles are present on right hand side. (Case 1).

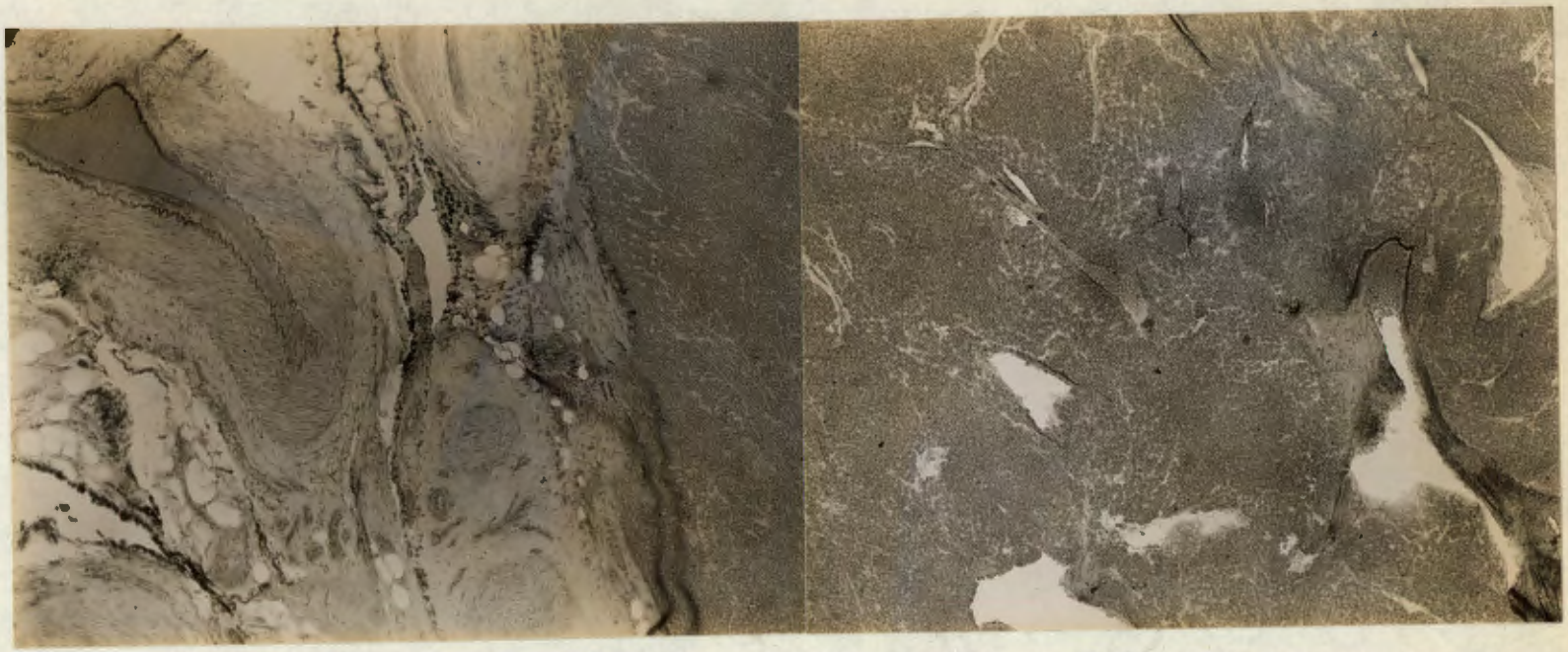


FIG. 38 HART'S X 60

Glomus tumour (Case 1) stained with Hart's Elastic Stain. Note the elastic tissue in large artery to left of picture and absence of elastic tissue in the vascular spaces of tumour on the right.

C. CLINICAL FEATURES

AGE:-

The age incidence of glomus tumours varies considerably. They have been found in patients ranging from 6 to 82 years. The commonest age is 25 to 40, when the glomus bodies are fully developed and most abundant. My series of cases varied between age groups of 18 to 86 years.

SEX DISTRIBUTION:-

C.M.Ottley (1942) stated that glomus tumours occur more frequently in males than females but that the subungual type, however, were more common in females. Most authors have refuted above findings as they find an equal distribution in both sexes. Amongst my series of 8 cases, were 4 females and 4 males.

RACE:-

Some authors have suggested that they are more prevalent in the Jewish race who are known to exhibit an over-active sympathetic nervous system (Stout 1935). There were 5 Europeans, no one belonging to the Jewish race, and 3 coloured patients in this series.

ETIOLOGY:-

A history of trauma is given in fifty percent of case reports. What part trauma plays, is not known with certainty. It may have the same significance in relation to its onset as other tumours, like sarcomas of bone. In two of my cases, there was a definite history of injury prior to onset of tumour.

SYMPTOMS:-

1. Onset: - The history is usually long, extending over many years. The longest history recorded was 43 years (A.P.Stout 1935) and the shortest was 2 weeks (Theis 1937). The initial symptoms may become noticeable during a pregnancy. (Case 2).

2. Pain:- The production of severe pain is of most significance and is the most constant finding. The severity of the pain is a most striking feature when one considers the size of the tumour and its innocent appearance.

The pain is paroxysmal in nature. An attack of pain comes on fairly suddenly, reaches its maximum intensity in about one minute after which it passes off gradually in space of 3 to 5 minutes. In between attacks the patient does not experience pain but complains of weakness of a limb. The pain is described most frequently as burning, bursting or

resembling a needle prick. The patients commonly complain of a splinter having penetrated the affected part.

The radiation of the pain is most interesting and helps one to differentiate it from other related conditions. It does not radiate along the pathway of a nerve in a definite manner but has a diffuse manner of spread. For example, when tumour is situated in the hand, the pain may localize itself in shoulder, side of chest and neck and even to hip area of affected side. This suggests that the pathway of referred pain is confined chiefly to sympathetic nervous system. Pain is produced by one of the following factors:-

a) Touch: Pain is initiated by the lightest touch as when clothing touches the affected part. As a result, the patient develops certain protective tricks which lead to characteristic mannerisms. When tumour is placed on the hand he may cover the tumour continually with other hand or when situated on a limb, the clothes are prevented from rubbing against the tumour.

b) Changes in Temperature:- Both heat and cold can precipitate an attack. The latter is found to be the more common of the two factors. Therefore, the attacks are more frequent during winter and at night when

the temperature drops. These patients wake up with the pain and are only relieved when the affected part is warmed up. In cases 7 and 8, pain was precipitated by heat and not cold.

c) Emotional Disturbance: The glomus tumour patients are usually highly strung and have a hyper-reactive sympathetic nervous system. Pain is therefore readily precipitated by a fright, anger or emotional upset.

d) Dependency: When tumour is situated on the finger, dependency of the limb will produce pain. To avoid this the arm is maintained in an elevated position.

3. Swelling:- A minority of the patients complain of a tumour or swelling. Occasionally, when a visible tumour exists, they describe an increase in size of the swelling during an attack.

4. Pigmentation of Skin:- The majority of patients will mention this feature. They describe a bluish area of skin or "mole" which changes to a reddish hue during an attack.

SIGNS:-

1. Dilated Veins (Figs. 43 and 55). This is a most constant finding and does not involve only the affected area on the hand but also most of the extremity.

The veins do not pulsate and there is no thrill palpable over them. This venous dilatation has not been mentioned by other workers.

11. Increased Sweating: The palms of affected hands are usually moist and sweat droplets may stand out prominently around the glomus tumour. (Fig. 40).

111. Wasting of Part: As result of pain which leads to disuse atrophy of muscles, one notices marked wasting of muscles. This is seen particularly in the hands where small muscles are affected. On removal of the tumour the muscles regain their former development.

1V. Increased growth of finger: This feature can sometimes be demonstrated in the affected fingers and can be confirmed by radiography. (Figs. 42 and 70).

V. Trophic Changes: These are most frequently seen in the nail which becomes ridged, irregular and brittle (Cases 2 and 4). In the case where subungual tumours occur, the nail becomes thinned or abnormally convex (Case 5).

The skin of a finger frequently appears shiny and thinned and the terminal phalynx tapers to a point (Case 1).

Vl. Horner's Syndrome: A Horner's syndrome was not detected in any of my cases although Barre (1920) and Couch (1941) found this feature in cases described by them. The syndrome is present usually during an acute attack of pain.

A Horner's syndrome is caused as a result of paralysis of the sympathetic nerve fibres to the eye. The presence of this syndrome in glomus tumour patients would be difficult to explain. Judging from the clinical features the tumour causes an irritative but not a paralysing effect on the sympathetic nervous system.

Situation: Glomus tumours are found most frequently in situations where the glomus bodies are present normally in largest numbers. They are by no means confined to these areas. They occur most frequently on the limbs, particularly nail beds and pulps of fingers. Very few cases have been described on other parts of the body.

In my series of 8 cases three occurred on the fingers, two on the palm, one on the wrist, one on the thigh and one on the leg.

P. Masson (1935) published a monograph in which he had 27 cases of glomus tumours. Fourteen occurred in fingers and hands, thirteen in other parts of body, while none occurred on the feet.

In the table cited below, C.M.Ottley (1942) gives the following table:-

S I T E

Upper limb	Thumb and fingers	75
	Wrist and hand	11
	Elbow and forearm	20
	Shoulder and arm	19
Lower limb	Toes	3
	Ankle and foot	6
	Knee and leg	18
	Buttock and thigh	16
Neck		1
Penis		2
Chest		2

The above situations in all the series suggest that in the upper limb a decrease in number of glomus tumours occurs as the proximal part of the limb is approached. This does not, however, hold true for the lower limb where the toes show the lowest incidence and the thigh and buttock the highest incidence of glomus tumours. This cannot be explained on anatomical grounds if the glomus counts of Popoff (1936) and Grant and Bland (1931) are correct.

Margaret Murray and A.P. Stout (1942) believe that glomus tumours occur elsewhere in body apart from the skin. Several authors found that tumours arise in a wider area than the limbs, and also in other zones than cutaneous area.

Among these unusual cutaneous situations mentioned are the following:-

Face :- 2 tumours were described by Butz (1940).

Eyelid:- Kirby (1941).

Ear:- Fernandez and Monserrat (1931) and Sannicondro (1936). Doubt exists whether these were tru glomus tumours.

Neck and back:- Kirchberg (1936).

Thorax :- Roger and Alliez (1938) described a case onlateral side of thorax in region of 12th rib.

Axilla:- Gumpel (1939).

Buttocks:- Lendrum and Mackey (1939). The glomus tumours described by them are of doubtful nature.

Penis:- Grauer and Burt (1939). They described two cases which were painless. This

feature places the diagnosis of glomus tumours rather in doubt.

During careful microscopic examinations of several preputial organs of man and monkey, I was unable to demonstrate the glomus body.

Tumours of Coccygeal Glomus: These have been described by Kalaczek (1875), Buzzi (1887), V.Hleb-Kosianska (1904) and Kopler (1936).

Amongst unusual deeper structures involved are the following:-

Muscles:- Andre Thomas (1933) described a patient with a glomus tumour in the vastus internus and in muscles around the internal condyle of femur.

Bones: Iglesias de Latorre, Gomez-Caniego and Palacias (1939) found a tumour buried within the terminal phalanx without involvement of soft tissues.

Joints: Hoffman and Ghormley (1941) found a glomus tumour inside the knee joint. It was the size of a lima bean and was removed from between the fibrous capsule and synovial membrane. Painful symptoms which had been present for 23 years disappeared and histology was that of a glomus tumour.

Tendons: Bergstrand (1937) found them in sheath of peroneal tendon near lateral malleolus. The

tumour, however, was painless and recurred after several attempts at removal.

Uterus: Durante and Leweland (1928).

Omentum: Kirschbaum and Teitelman (1939). Unfortunately histological pictures were not produced in their paper.

In the majority of cases they occur as single tumours, but multiple swellings have been described in the following situations:-

Over Skin of Body: Weidman and Wise found multiple glomus tumours of order of Telangiectasis. They found 48 tumours widely spread and not painful. The histological picture leaves the diagnosis of multiple glomus tumours in doubt.

Foot: A. P.Stout (1935) described a case of multiple tumours occurring in the heel.

Bergstrand (1937) also described multiple glomus tumours behind tendo-achilles.

Size of the Tumour: Glomus tumours grow exceedingly slowly and have never been known to attain a great size. The majority are small and measure only a few millimetres. The largest on record measured 1½ by 1 inches. (Lendrum and Mackey 1939). The tumour of Case 1 measured 1½ by 1 centimetres.

Presentation of Tumour:

The tumour presents itself in one of the following ways:-

1. A slightly raised area under the skin with marked pigmentation of the tissue overlying the skin.

This tumour has arisen from a glomus body situated in reticular or deeper part of the dermis and during growth has extended, partly towards superficial and partly to deeper areas. In this type of tumour, three quarters to seven-eighths of tumour lies beneath the skin and is the commonest type encountered. (Case 1. Fig. 40).

2. Pedunculated growth: Here the tumour arises from a glomus body placed in the superficial or papillary portion of dermis and consequently grows on to the surface. This type of case is encountered infrequently and was clearly demonstrated in Case 3 and in the photograph reproduced from case of O.T.Bailey's (1935) (Fig. 64).

3. Absence of any swelling: This may present itself in one of two ways.

a) As a small bluish area, most commonly found in the nail-bed (Fig. 74) and

b) No evidence of either tumour or colouration. The latter type of case is often labelled as physcho-neurosis, causalgia or neuritis.

In a) the tumour lies in the nailbed and is not visible on account of its subungual position. Sometimes when placed in the distal nailbed, a small purplish tumour is just visible under edge of nail.

In b) the tumour has developed from a glomus body which is situated deep in the subcutaneous tissue and the growth has extended inwards. In this type of case, the diagnosis is made after careful localization and exploratory operation.

Character of overlying skin:

This is most frequently described as purple or blue. During an attack of pain the colour becomes changed to red. The surrounding skin shows several dilated vessels.

Pulsation of the tumour is usually not demonstrable.

Palpation reveals the following:-

Increased Warmth: The affected finger and the corresponding hand feel warmer than the opposite side. (Figs. 45 and 57).

Tenderness: The exquisite tenderness of the tumour is the most important finding in the diagnosis. As a result of this tenderness the examination of the tumour and its clear definition is carried out with the greatest of difficulty. The mere approach of the examiner will cause the patient to wince and protect the affected part.

The tumour has a doughy consistency and a smooth surface. With the exception of the pedunculated tumours, the edge is difficult to define on account of the tenderness and softness of the tumour.

As the tumour is most frequently situated in the corium, the overlying skin is attached to it and often appears wrinkled. The deeper portion is not attached to the deep fascia or the muscles. At operation, an afferent vessel to the tumour may be demonstrated. Palpable pulsation and a thrill are absent.

Complications:

1. Haemorrhage: In few cases of longstanding complicated by incorrect local treatment and infection, the tumour may ulcerate and lead to a marked haemorrhage.

2. Malignancy: This complication is refuted by most authors. Only 2 cases have been described as undergoing malignant changes.

a) Kirschbaum and Teitelman (1939) described a malignant tumour of omentum which involved stomach and metastasised to liver.

b) Soiland (1937) described a malignant glomus tumour in the pectoral region.

SPECIAL INVESTIGATION:

L. Temperature Recordings:

By means of an electric thermocouple, increased

temperatures of affected parts can be recorded. (See Figs. 45 & 57).

2. Radiography:

In the deepseated tumours of the phalanges, pressure necrosis of the bone can be demonstrated. The bone, most commonly the terminal phalanx, shows a smooth, saucer-shaped area of erosion (Oughterson and Tenant) (1939) and case 1 (Fig. 42).

Not infrequently , there is evidence of increased length of a phalanx. (Cases 1 and 4).

3. Oxygen Estimation of Blood:

An increase in the percentage of oxygen in the blood taken from a finger was shown in Case 1. Here the blood from a vein equalled in oxygen content that of an artery. Distances away from the tumour showed a proportionate decrease in the figures.

4. Oscillometry:

This may show an increased amplitude of pulse wave (Fig. 59)

5. Venous Pressure:

In one case, a slight increase of the venous pressure was demonstrated in an affected limb as compared with a corresponding point on the opposite side.

DIAGNOSIS:

This is made by finding an exquisitely tender tumour of purplish colour and of small size in the skin. The tumour is of slow growth and found most frequently in pulps of fingers and nailbeds. Several tumours occur in the above regions and have to be mentioned in the differential diagnosis.

1. Subungual melanoma:

A glomus tumour is most frequently mistaken for the above condition. The absence of pain and shorter history make the diagnosis of melanoma more definite. Where the latter undergoes malignant changes, metastases to glands, lungs and liver soon become evident. The above conditions occur most commonly on the toes where glomus tumours are not commonly seen.

2. Pulp Space Infection:

The very sudden onset with continuous throbbing pain, excludes a glomus tumour. In some cases of pulp infection, a sequestrum or chronic osteitis is shown on X-ray.

3. Neurofibroma:

A small neurofibroma on the hand may cause some difficulty in the diagnosis. They are often pigmented

and very tender. The absence of dilated veins, increased sweating and trophic disturbances, makes diagnosis of glomus tumour unlikely.

4. Subungual Clavus or Corn

This is most frequently found on the toes where glomus tumours are uncommon. They are very painful, however, and can readily be mistaken for a glomus tumour.

5. Subungual Exostosis

This is most frequently found in the toes and although very painful is easily demonstrable by means of X-rays.

6. Subungual Haematoma

The sudden onset and definite history of trauma would establish the diagnosis.

7. Angioma

An angiomatous growth when situated on the hand and complicated by presence of phleboliths, will be tender and difficult to diagnose.

8. Single cutaneous leiomyomata

These tumours can be most difficult to distinguish.

There are, however, several points of differentiation.

a) Site:- They occur most frequently on genital organs, nipple, face, anal region and umbilicus (A.P.Stout 1937).

b) Absence of discolouration of the skin.

c) Consistency is firm or hard.

d) Absence of diffuse radiation of pain.

e) Absence of dilated veins.

f) Absence of increased temperature.

g) Absence of Horner's syndrome

h) Normal oxygen percentage of venous blood (Case 11).

PROGNOSIS

With correct diagnosis and removal of tumour, the prognosis is excellent.

Local recurrence after operation has been reported several times (Lendrum and Mackey 1939, Lewis and Geschickter 1935, Stout 1935) but there seems no reason to doubt that it was due to incomplete removal.

TREATMENT

Complete excision of the tumour with area of neighbouring skin offers the only form of treatment and leads to a permanent cure.

In carrying out this small operation, it should be borne in mind that the tumour is apt to resist local anaesthesia (Adair 1934, and Case 3).

The tumour has been found to be insensitive to radiotherapy in 2 cases in which it was tried. (Mueller 1939).

Where a wrong diagnosis was made, amputations of fingers were performed in several cases.- (See Case 5). A cervical sympathectomy was performed in one case without amelioration of the symptoms. (Bergstrand 1937).

D. THE CAUSATION OF PAIN IN GLOMUS TUMOURS

When one examines a patient suffering from a glomus tumour, one is immediately struck by the intensity of the pain and the exquisite tenderness. Why should a tumour of such small proportions produce such acute symptoms?

Masson attributed the pain to pressure on the Pacinian corpuscles, highly specialised end organs of touch sensibility. He states that these bodies are particularly numerous where glomus tumours are found and present a flattened appearance.

This may hold true for cases where the tumour is confined to the hands but would be impossible to correlate with tumours in unusual situations like arm and thigh where Pacinian bodies are never found.

On the basis of increased tension in the tumour, the pain can readily be explained as follows:-

The glomus tumour is enclosed in a well developed collagenous capsule, in which large nerve bundles and fibres are embedded. Masson has also demonstrated the distribution of medullated nerve-fibres amongst the glomus cells. From the physiological aspect we learned that a large volume of blood may flow through the normal glomus, consequently a considerably larger amount will pass through the glomus tumour under certain conditions. These include changes of temperature, mechanical stimulation and interference with the sympathetic nervous system which is brought into play chiefly by emotional upsets. The effect of increased blood volume leads to increased tension in the tumour and therefore pain.

A simple test which confirms the above suggestion is the venous congestion test.

When the cuff of a sphygmomanometer is applied to the affected arm and inflated, the patient experiences pain when the diastolic blood pressure is reached. As the pressure goes up, so the severity of the pain increases. At a point where the systolic blood pressure is reached, the pain suddenly disappears.

This suggests that pain is due to vascular tension which is highest when the veins are compressed but disappears when the arterial pulse is blocked and therefore the blood

flow to the tumour diminished.

In the subungual glomus tumour (Fig. 74) owing to its position and firm texture of the tissues of the nailbed, tension in the tumour becomes very great. It is therefore the most painful glomus tumour found in the body.

CASE HISTORIES

E. CASE 1.

J.C. aged 54 years. Coloured male

Labourer - South African Railways.

Complaint: 1. Painful right thumb, duration 6 years.
2. Swelling of forehead for 5 years.

History: Six years ago he experienced a sudden pain in terminal phalanx of his right thumb. This was not preceded by any trauma to the finger. He felt the pain in the pulp of the finger and attributed the cause to a splinter. He did not notice any swelling at the time. The patient was able to continue his duties as a labourer but was always conscious of a prickly sensation in his finger. The pain was intermittent in nature and, with passage of time, gradually became worse, causing him to change his job to light kitchen duties.

A year after the on-set he noticed a small lump, smaller than a split pea, on the pulp of the right thumb. This gradually enlarged up to its present size, to that of a small bean.

Pain: The patient described the pain of excruciating nature and resembling a thorn penetrating the soft tissues. It radiates to the other fingers and causes his hand to feel "lame". At times it radiates along radial border of forearm as far as the

elbow. It comes on in paroxysms, is of sudden onset and brought on by the following factors:-

Touch: even of the lightest degree as when brushing his thumb against his clothes brings on an acute attack of pain. This has resulted in a characteristic attitude of his thumb in order to protect it from being touched. He buries the thumb in palm of right hand and flexes the other fingers over it.

Cold also brings on the pain, which comes on more frequently during the night. The pain wakes him up and he has to warm his hand before he can settle down again for the night. He prefers the warmer weather.

Emotional upsets, like nervousness, anger or excitement will bring on an attack. When pain is of maximum intensity the swelling becomes larger and is slightly raised above the surface. It also assumes a red colour.

Sweating: There is continuous sweating of skin of terminal phalanx of the thumb. This is increased during exacerbations of pain. As a result of loss of sleep he has lost 10 lbs. in weight.

For fear of losing his job he did not report at an earlier date.

Cardio-vascular symptoms are absent. There is no shortness of breath on exertion with absence of tachycardia and palpitations.

Fig. 39

Lipoma on Forehead

Fig. 40

Glomus Tumour of Right Thumb. Note the presence of sweat droplets over tumour and middle of distal phalany.

The forehead swelling started 5 years ago when he noticed a small nodule the size of a marble on his head. It gradually increased in size to that of a golf ball and is completely painless.

Previous History: Nil of note.

Family History: He has 7 healthy children. No similar lumps in his family.

EXAMINATION:

General: Patient has anxious expression and face is drawn. (Fig. 39). There is obvious loss of weight. He is in a state of nervous tension and finds it difficult to relax his muscles even when undergoing the simplest examination. His mucuous membranes are well-coloured. Teeth are septic. Temperature is normal.

Pulse: Rate is 76 per minute with regular rhythm and normal volume.

The radial and temporal arteries both sides are thickened and tortuous.

His feet are cold, with evidence of sweating on medial aspects.

Pulsations of both post-tibial and dorsalis pedis arteries are palpable.

Locally: The right thumb is held in characteristic posture, lying across the palm and in slight flexion.

Fig. 41

Fig. 42

Fig. 41 shows wasting of terminal phalanx of right thumb and wrinkling of skin over the tumour. Right terminal phalynx appears longer than on the left side. The difference in length is exaggerated by patient flexing terminal interphalangeal joint of left thumb.

Fig. 42. Right terminal phalanx is longer than on the left side. The saucer shaped area of erosion of right terminal phalanx is evident.

There is wasting of muscles of thenar and hypothenar eminences.

There is slight wasting of interossei of right hand. The veins on dorsum of right hand and forearm are very prominent. (Fig.43). The right thumb is narrower than the left and has a tapering terminal phalanx. (Fig.41).

The skin over dorsum and tip of right thumb appears smooth and atrophic.

The nail is thickened and ridged longitudinally and there is absence of normal pink colour of the nail bed.

There is no difference in length of the two thumbs.

Pulsation of veins of right hand is not visible.

The skin over volar-surface of terminal phalanx has a bluish red colour and is wrinkled.

Beads of perspiration stand out over this portion of skin (Fig.40) Sweating is present in surrounding skin but is less well-marked.

On the volar and lateral aspect of this portion of the thumb is a dark purplish area measuring 1½ x 1 cm. It is raised 2 mm. above the surrounding skin and is oval in shape with its long axis lying in longitudinal axis of thumb. The surrounding skin contains multiple raised spots, the size of a pin's head, and resembling small papules. There is no evidence of visible pulsation. Capillary pulsation is normal.

On palpation the right hand feels warmer than the left, whilst the right thumb feels warmer than the rest of

Fig. 43

Fig. 44

Fig. 43 shows marked dilatation of veins on dorsal surface of Right limb before operation.

Fig. 44. Marked decrease in size of veins of the right limb 6 months after operation.

the hand. There is no pulsation of the pulp. Thrills are absent. By reassurance of patient and very gentle palpation of the pulp of right thumb, a small lump of doughy consistency could be detected. It is attached to overlying skin and the edges are difficult to define. The deeper portion of tumour could not be palpated on account of pain. The tumour is exquisitely tender and even the lightest touch brings on pain. The surrounding skin is hyperaesthetic and tenderness becomes more marked as the tumour is approached. As a result of the examination there was increased sweating over the tumour.

The power of the right hand is not diminished.

Auscultation of hand and forearm revealed no murmurs.

The forehead swelling: (Fig 39).

This is a well-defined cystic lump the size of a golf ball situated above bridge of nose in centre of forehead. The skin over the swelling has a bluish tinge. The skin is not adherent to the lump and the edges are well-defined. It is not attached to the deeper structures.

Cardio-vascular System:

There is no cardiac enlargement present on clinical examination. The heart sounds are closed and no murmurs are audible.

Blood Pressure Recordings:	R.	L.
Arm.....	170/90	162/90
Leg	175/90	180/95

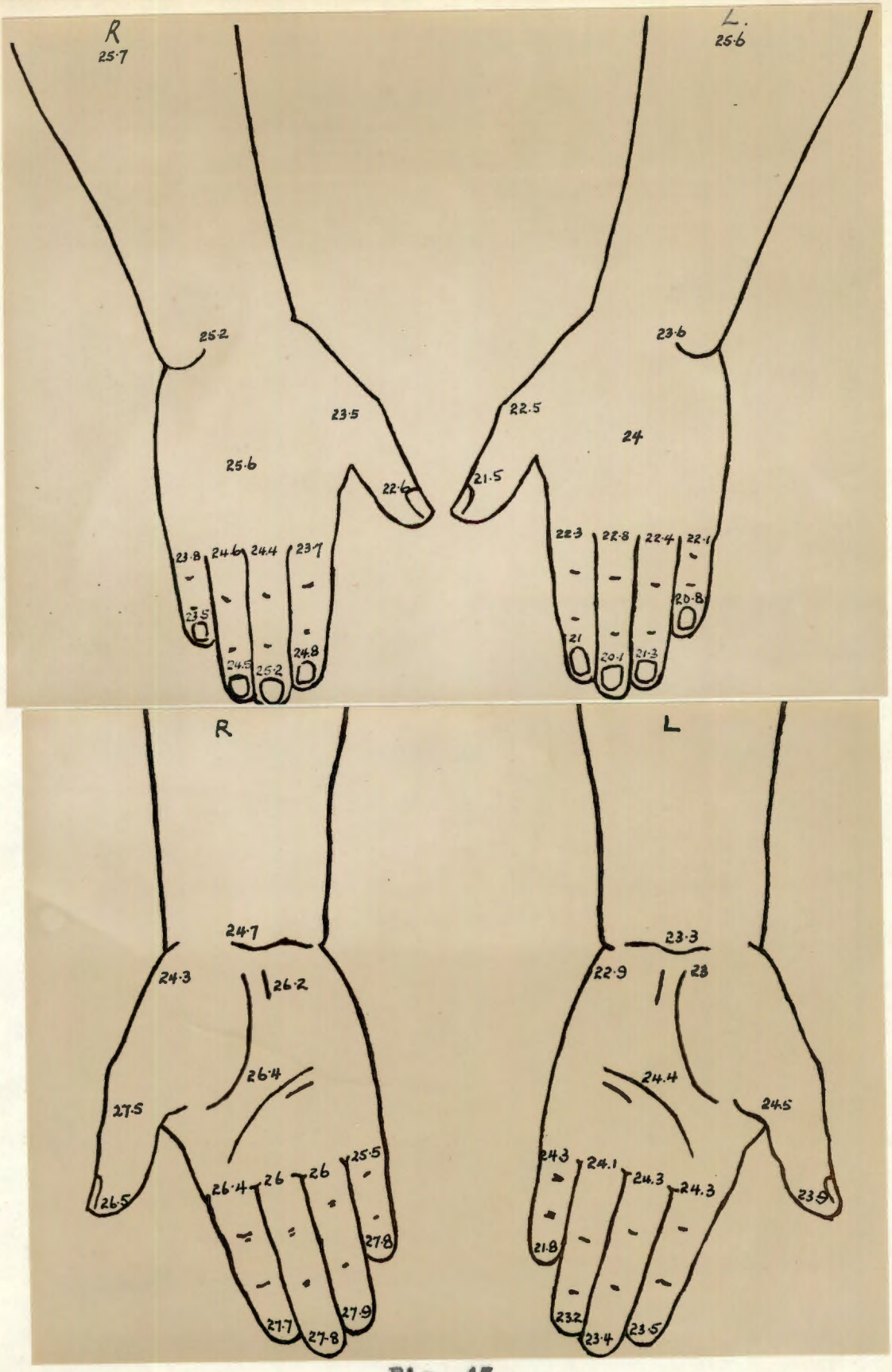


Fig. 45

Temperature charts before operation showing marked difference between the two hands.

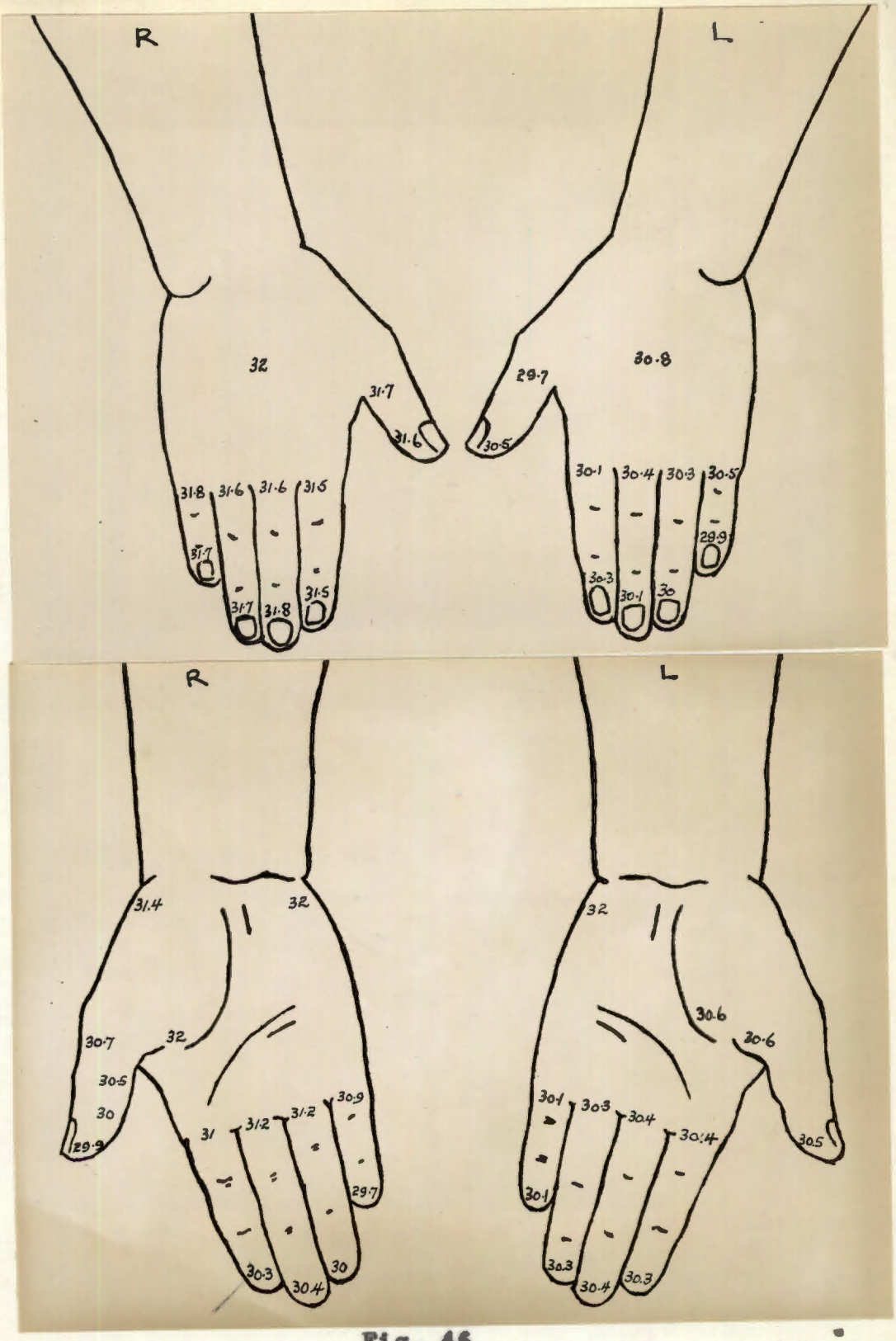


Fig. 46

Charts after operation showing the small difference in temperatures.

Central Nervous System:

Pupils are equal and react to light and accommodation. There is an absence of Horner's Syndrome. Cranial nerves are intact.

Reflexes:

Knee-jerks slightly exaggerated both sides.

Ankle-jerks present and equal.

Sensory disturbance - Marked hyperaesthesia to lightest touch confined to tumour area as previously described.

Motor involvement - nil. The ulnar, median and radial nerves are intact. The wasting of muscles was due to disuse atrophy.

Investigations:

1. X-rays - heart.

Heart is of normal size and shape.

Phalanges (Fig. 42) The right terminal phalanx shows a well-marked local area of destruction on volar surface of bone corresponding to site of tumour. The rest of the bone and phalanx shows normal calcification. The right terminal phalanx is narrower, more pointed and is an $\frac{1}{8}$ inch longer than the opposite side.

Arteriograms (Fig. 47,48). Comparing the artery of thumb with a normal arteriogram, there is obvious enlargement and tortuosity of this vessel. The glomus

Fig. 47 Fig.48

Comparison of arteriograms of normal hand and that of Case 1 respectively. Fig.48 shows dilatation of all the arteries of the hand. Note tortuousity and marked dilatation of digital artery of thumb.

portion is, unfortunately, not well-known, being present as a loop proximal to the depression in the bone. The other digital arteries are also dilated.

2. Venous Pressure:

	Left Arm	Right Arm
Cubital Fossa....	4. 75 cm.	4.75 cm.
Base of Thumb....	2. 75 cm.	4.5 cm.

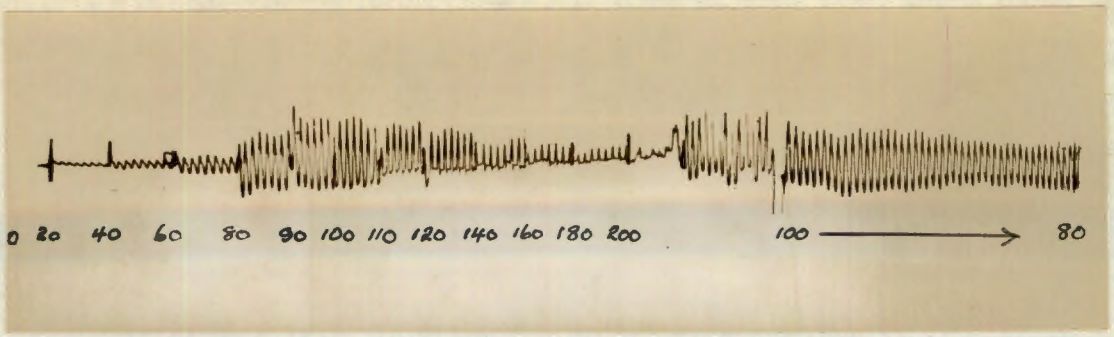
This shows a difference of 1. 75 cms. on the two sides.

3. Skin Temperatures: determination by means of a thermocouple. (See Charts - Fig. 45). The most marked difference in temperature is demonstrated at base of thumbs on flexor aspect where readings are 27.5°C and 24.5°C on the right and left sides respectively. (Fig. 45).

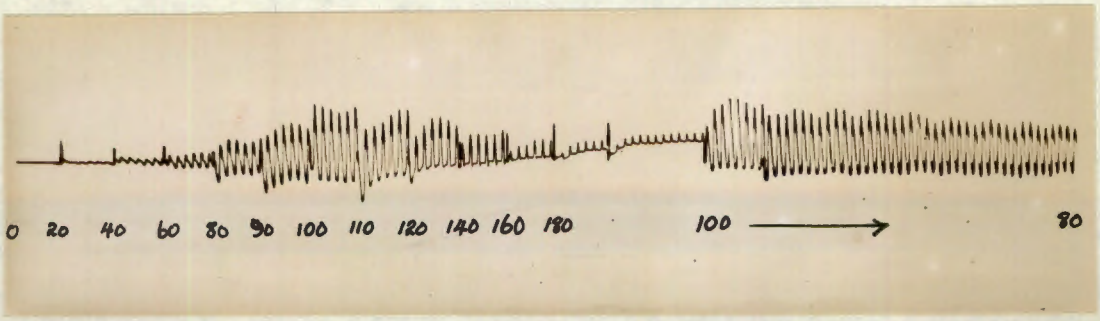
4. Oxygen Estimation of Blood (cc. of oxygen per 100 cc. of blood).

by means of Van Slyke's Monometric Method.

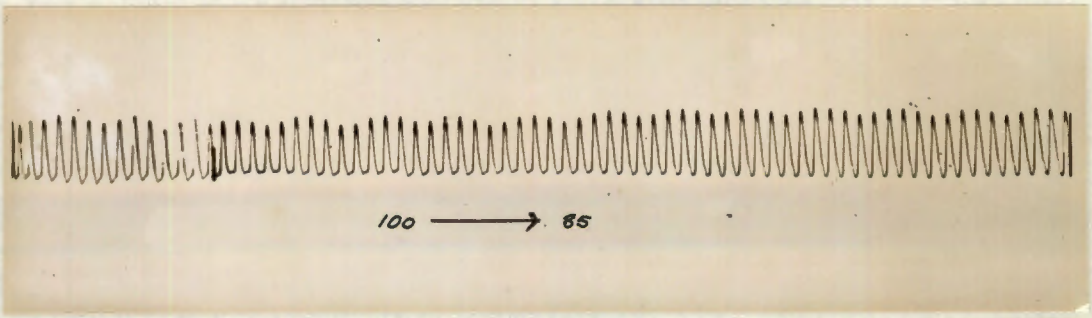
(See next page).....



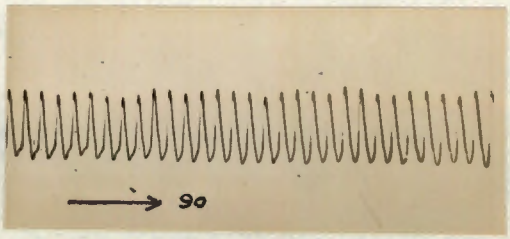
Middle of Right Forearm



Middle of Left Forearm



Middle of Left Forearm



Middle of Right Forearm

Fig. 49

Oscillograms of two limbs. Amplitude of pulse waves same in both arms.

Situation of Vein	Vol. Percent Oxygen Right Arm	Vol. Percent Oxygen Left Arm
1. Cubital Fossa	16.28	16.21
2. Right Wrist - dorsal surface distal end of radius	16.81	14.14
3, Right Base of Thumb (Dorsum)	19.11	15. 19
4. Dorsum of hand (Central portion)	17.37	14.97

The oxygen percentage of each blood sample was calculated twice. If the difference in readings were more than 0.5 per cent, the sample was discarded and new blood sample was taken.

5. Oscillometer Reading. (Fig. 49).

Oscillogram taken at middle of forearm gave equal values on both sides.

The highest reading of Right Hand = 15mm.of mercury

The highest reading of Left Hand = 14mm.of mercury

(Fig. 49)

6. Venous Congestion Test:

The cuff of a sphyg-momanometer is applied to affected arm. The pressure in the cuff is raised and patient is instructed to indicate when pain is felt in the affected thumb. It was found that pain commenced at 80 mm. pressure and increased in severity as pressure in the cuff increased.

Fig. 50

Fig. 51

Fig. 50 shows appearance of glomus tumour soon after removal measuring 1½ Centimetres in length. In Fig. 51 the tumour is seen after fixation in Bouin's Solution.

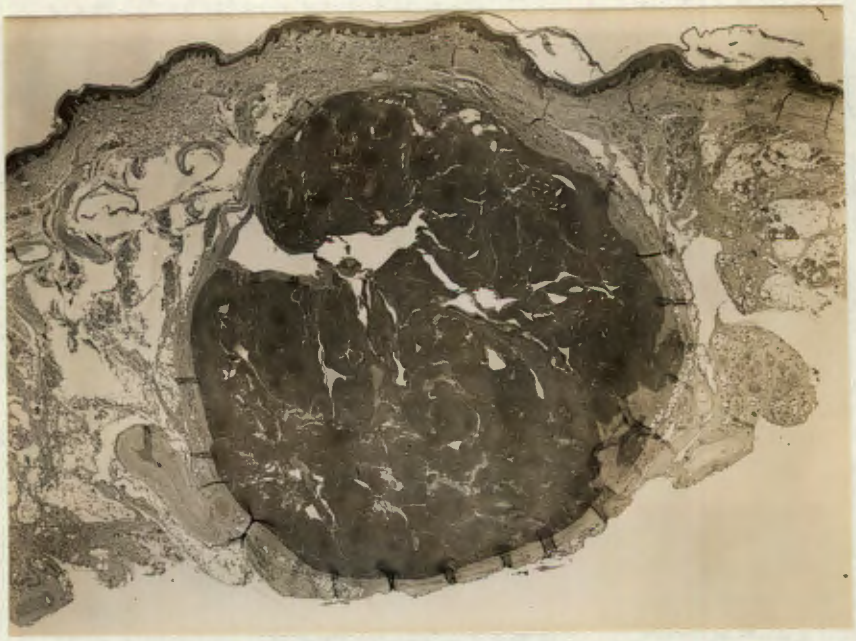


Fig. 52 H & E X 114

Section from middle of Tumour showing a well-marked capsule and a large artery below and to the left. This is the afferent artery to the tumour. On the right of tumour, large nerve bundles are visible. The tumour is composed of bundles of tightly packed cells.

At 160 mm. pain was less acute and gradually eased off until 200, when pain in finger disappeared.
Slight hyperaesthesia of skin over tumour persisted.

This test suggests that pain of a glomus tumour is due to <u>increased vascular tension</u>. This has been discussed under the mechanism of pain production in glomus tumours.

<u>OPERATION 6. 2. 47</u>

Under general anaesthesia an arteriogram was done using the brachial artery in middle of arm as site for injection of the diodrast. A circular incision was made on volar surface of thumb, enclosing the tumour, and leaving a skin margin of 1-2 mm. The tumour was excised together with overlying skin and subcutaneous tissue. The dissection was carried down to flexor surface of phalanx and to insertion of flexor Pollicis Longus Tendon. The tumour was not adherent to these structures.
It was well-defined and encapsulated and measured 1½ x 1 cm. (Fig. 50)
It had a bluish purple colour.

As the skin defect was too large to close, a skin graft was applied, making use of skin, size of postage stamp, from thenar eminence.

<u>Forehead Swelling:</u>

A transverse incision, three inches in length, was made over the tumour. The latter shelled out with ease and did not show any large vessels.

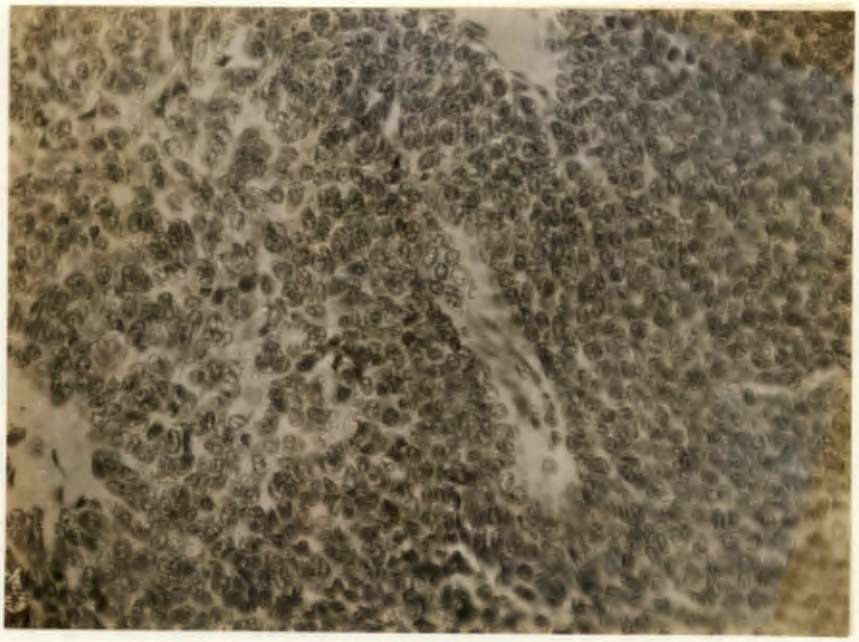


Fig. 53 H & E. X 440

High power of glomus tumour showing typical closely packed glomus cells with dark-staining nuclei.

Macroscopic appearance: It had all the appearance of a well-encapsulated lipoma. There was no evidence of haemangiomatous structure as suggested on clinical examination.

Macroscopic appearance of Tumour from Right Thumb.(Figs. 50,51)-

Transverse section through specimen, showed a well-defined tumour embedded in soft tissue of finger. The cut surface of tumour has a whitish appearance and the central portion shows several cystic areas. The tumour is divided into two unequal portions, the smaller being uppermost.

MICROSCOPIC APPEARANCE (Figs. 52 and 53).

Shows a very cellular tumour with closely-packed epithelial cells. There are comparatively few vascular spaces and this type corresponds to Paucivascular type of tumour described by Masson.

A large space, nearly dividing the tumour into two portions, corresponds to the afferent artery of the tumour. The wall of the artery is still well-preserved at the site of entry to tumour. Below and to the left side, outside capsule of tumour, a transverse section has been made through a large artery. Smaller intercellular clefts are present in rest of the tumour. These clefts represent vessels of smaller calibre coming from the afferent vessel.

Completely surrounding the tumour, we see a well-defined capsule. The latter is composed of dense connective tissue containing numerous small nerve-endings.

In the tissue around the tumour, several nerve bundles are evident. These are well-shown below and to right of tumour. Numerous Pacinian corpuscles are also present, some having a flattened appearance. Above and to the left of tumour, a normal glomus is present. (Fig. ..... 52).

Progress:

The patient made an uneventful recovery and had immediate relief from pain. The skin-graft grew satisfactorily.

14. 8. 47: Oxygen estimation of blood taken from bases of thumbs.

Vol. Present Oxygen

Sample	R.Hand	L. Hand
1.	18.46	17.45
2.	18.53	17.52

Although the oxygen content was slightly higher in the Right hand, the difference was appreciably less than previously recorded.

Pain was absent and patient was gaining weight.

The prominence of veins on dorsum right hand was still evident but to a lesser degree (Fig. 44).

Right hand shows slightly higher temperature charts than on the left side, but not so marked as before operation. (Fig. 46). This may be explained by the enlargement of digital arteries which had not returned to normal.

CASE 2

Oct. 1944

Mrs J.L. Aged 26. European Female

Occupation-----Housewife

Complaint: Painful left index finger for two months.

History:

During the latter part of her pregnancy, patient noticed a small tender pimple, resembling a blood blister, on pulp of left index finger. She attributed this to trauma resulting from use of knitting needles.

This small raised area was red in colour and sensitive to touch. After trying to open it with a needle it bled profusely for more than an hour.

Following this irritation, the nodule greatly increased in size and the pain became very severe. It was of a burning nature and brought on by exposure to cold and light touch. The pain did not radiate up her arm but kept her awake at nights. Dependency of left hand brought on the pain, causing patient to keep her hand in an elevated position.

There was further bleeding from the affected area 6 weeks after the onset. By now the nodule was the size of a small pea and an attempt was made to cauterize it with copper sulphate, without success.

Patient noticed that left hand felt warmer than the right with increased sweating of the left palm.

Fig. 54

Photograph of glomus tumour on index finger of the left hand.

On Examination:

Patient was in excellent general health and was 36 weeks pregnant. The cardio-vascular system, pulse and blood pressure were normal. Horner's Syndrome was absent.

Local Examination

Local examination revealed a small raised purplish nodule, the size of a small pea, in centre of pulp of left index finger, the surface showed superficial ulceration without evidence of any discharge. (Fig. 54). The edges of the tumour was difficult to define on account of the exquisite tenderness on palpation.

There was marked warmth of the whole hand, particularly the affected finger in which the digital pulses were palpable.

The left hand had a reddish colour in contrast to index finger which appeared pale.

The left palm felt moist due to increased sweating. The veins on dorsum of left hand were very pronounced compared with right hand. (Fig. 55).

The radial pulse in left hand was definitely bounding.

Measurements of two index fingers did not reveal any difference in the lengths.

INVESTIGATIONS:

Temperature Recording: By means of thermocouple. (Fig. 57). This showed a marked difference in the readings

Fig. 55

Fig. 56

Fig. 55. Note the dilated veins on dorsum of left hand compared with right hand. The Tumour can be seen on index finger of left hand. Fig. 56 shows disappearance of enlarged veins 2½ years after operation.

on the two sides. The highest temperature, 32.5°C., was recorded over volar surface of left terminal phalanx, whereas the corresponding point in opposite hand was 30.8°C. The most marked differences in temperature were recorded at bases of index fingers.

Oscillometry: (Fig.59).

The oscillograph tracings taken from middle of forearms, showed that the amplitude of the pulse waves in the left hand were increased.

Diagnoses & Treatment:

A diagnosis of a glomus tumour was made and operation was performed by Prof. Saint, under pentothal anaesthesia. A vertical incision, half an inch long, was made in the pulp of finger, and a small encapsulated tumour measuring 6 x 8 mm. was carefully removed. The patient had immediate relief from pain following the operation.

X-Ray Examination: Showed absence of rarefaction or cavitation of terminal phalanx. (Fig. 60).

Microscopy: (Figs. 61, 62 and 63).

The tumour is situated in the superficial portion of the dermis. It does not show the well-marked encapsulation of Tumour of Case 1. The skin over tumour has been totally destroyed. One edge of this ulcerated surface shows a narrow layer of prickle cells with destruction of

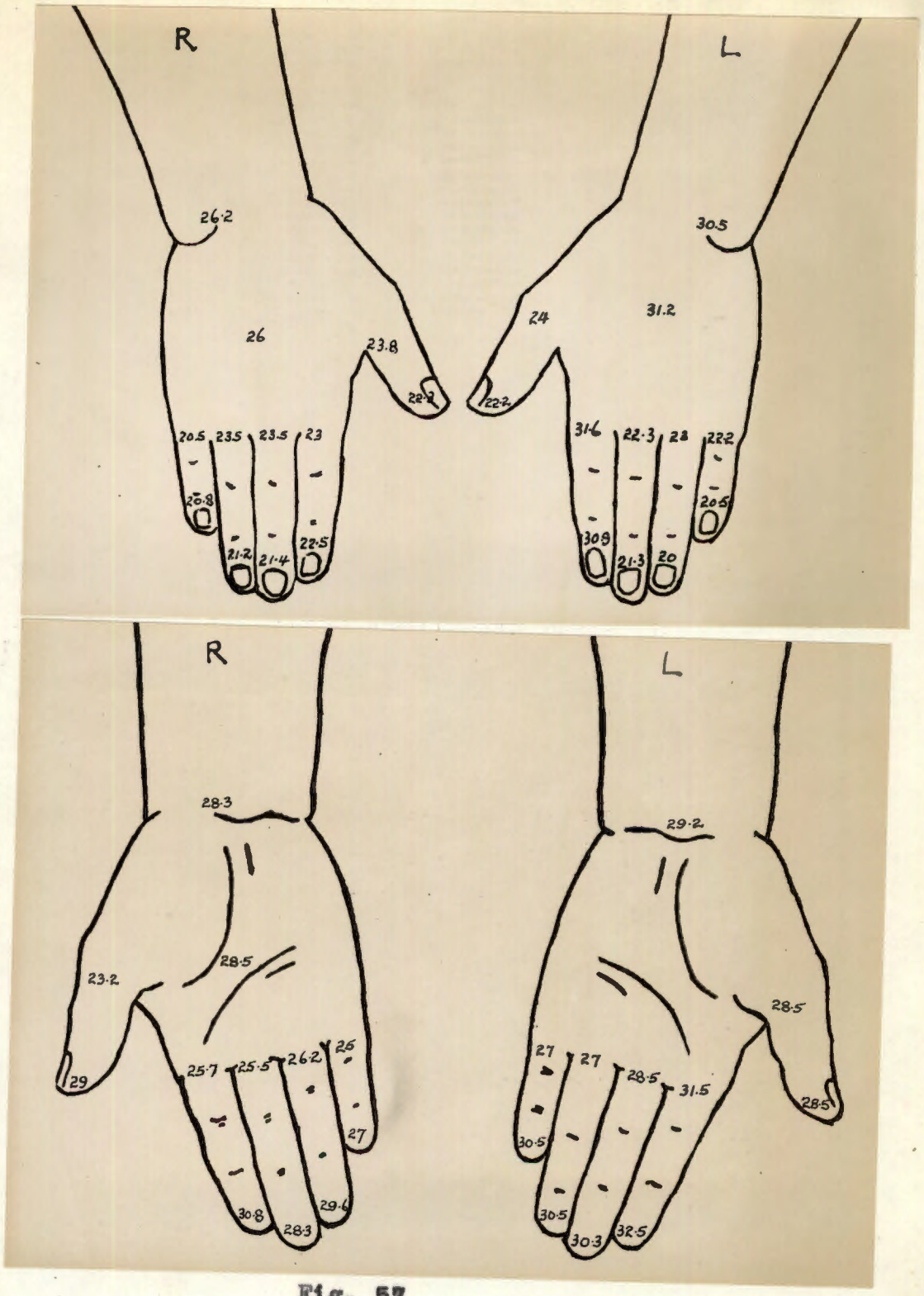
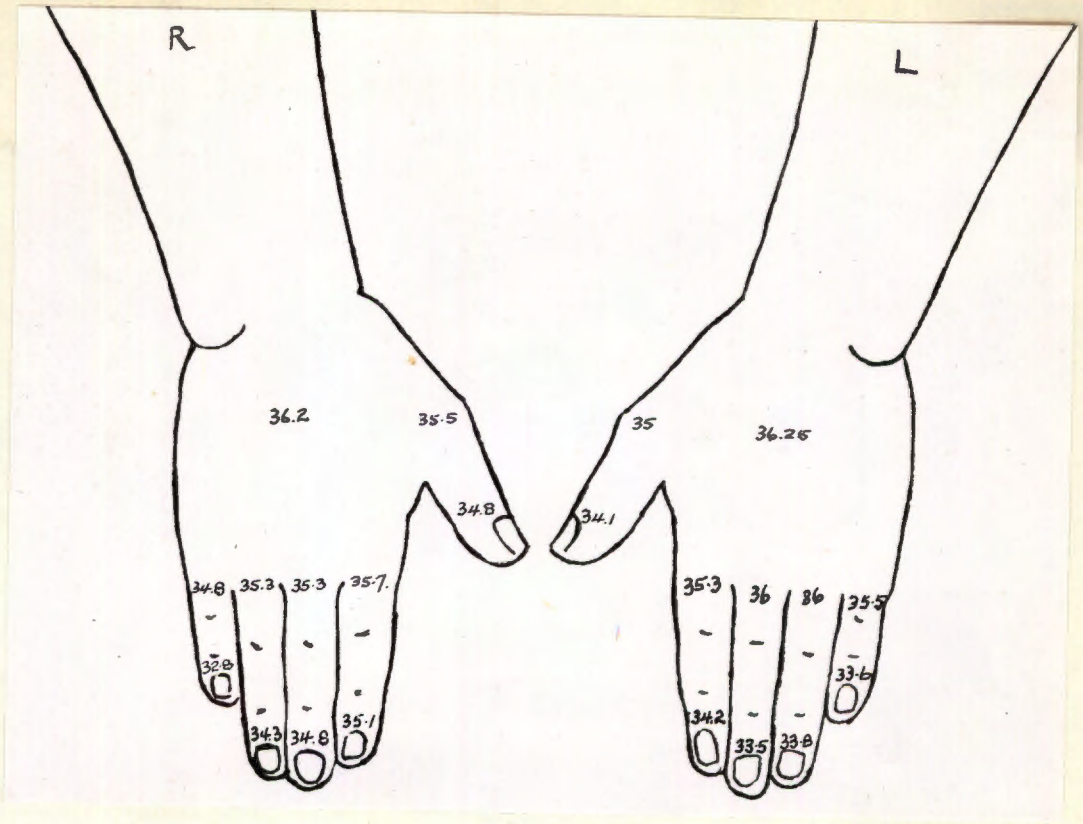


Fig. 57

Above charts demonstrate the marked differences of temperatures in the two hands before operation. Note the higher temperatures of left hand.



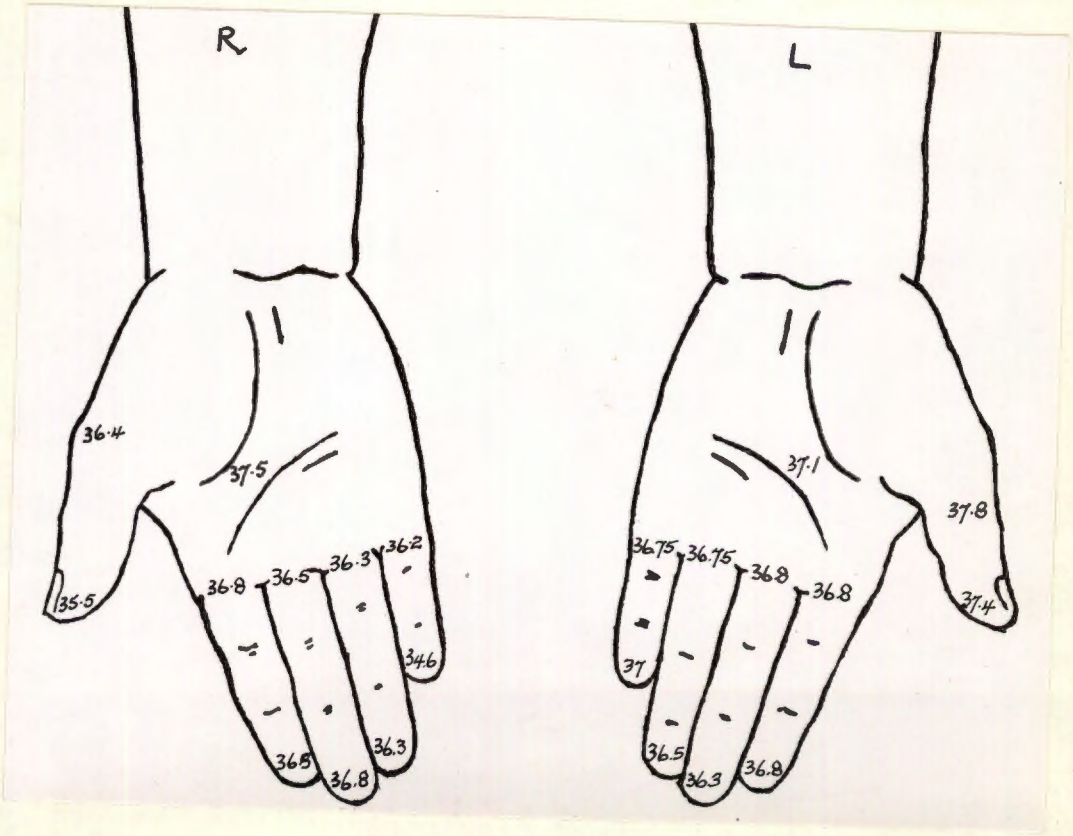


Fig. 58

Above figures show the small differences of temperatures of two hands 2½ years after operation.

of stratum corneum. On surface of tumour are many chronic inflammatory cells of lymphocytic type.

The tumour is divided by numerous fibrous septa into smaller compartments. Each compartment contains the characteristic epithelioid or glomus cells. These cells are closelypacked and are congregated around vascular spaces.

In the deeper portion of the dermis underlying the tumour are large vessels and nerves. Large pacinian bodies, having a flattened appearance, are found in this region.

Numerous sweat glands are also seen and must not be mistaken for normal glomus bodies. A few of these bodies can be seen to the right of the tumour.

Progress:

She was completely free from pain in her finger until 17. 1. 47 - nearly 2½ years later when she complained of sudden onset of pain in the same finger. Pain was of a prickly nature and brought on by firm pressure. The index finger was not affected by heat or cold. She was conscious of a small nodule in scar. At the time of onset patient was 5 months pregnant.

On examination I found a healthy scar on pulp of left index finger. In centre of scar could be seen a small white area the size of a pin's head. It was of firm consistency and slightly tender. There was very slight, if any,difference in size of the veins on dorsal surfaces of

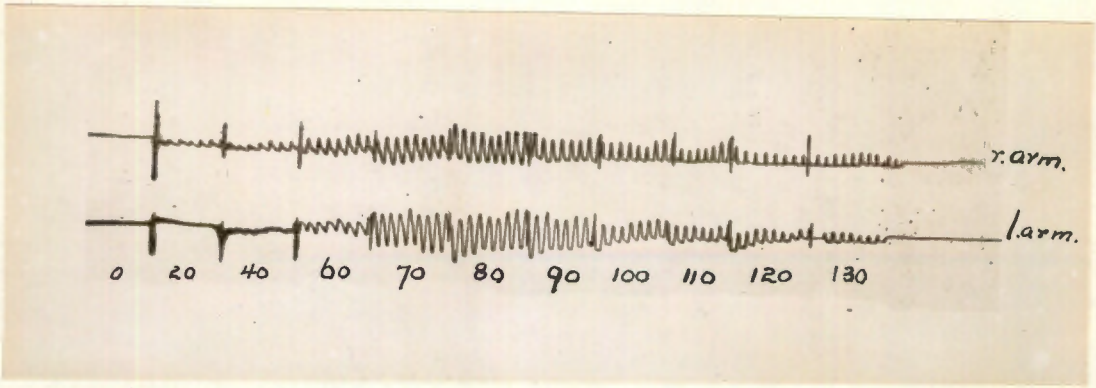
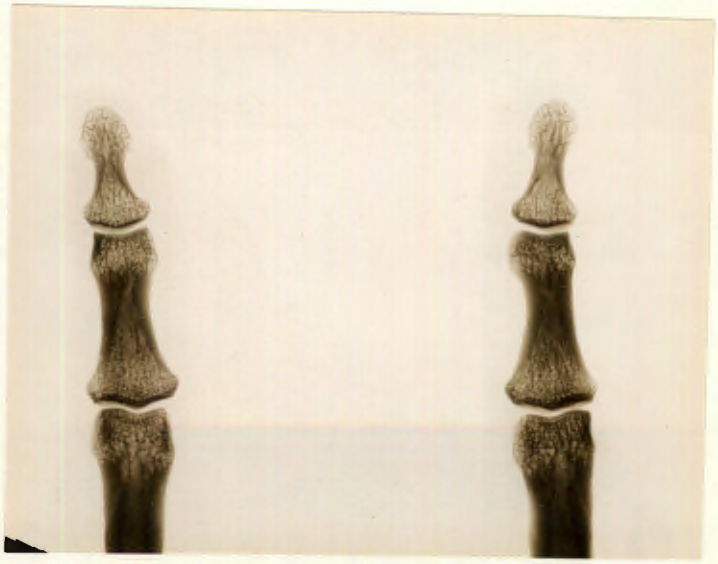


Fig. 59

Oscillograph tracings taken from patient before operation showing the increased amplitude of the pulse waves in the left arm.



L. R.

Fig. 60

X-Rays show no bony changes in left index finger.

of hands.

At the time of examination I was unable to make a definite diagnosis. The area resembled a small fibrous nodule in old scar tissue, but one had to bear in mind a recurrent glomus tumour in view of patient's previous history.

I had been following the progress of this case and 3 months later the pain had disappeared and there was no further growth of the nodule.

The temperature reading of affected hand had undergone a marked change and would be interesting to record. (See Fig. 58). Note the same temperatures on Flexor surface of bases of index fingers.

A photograph of hands, taken 2½ years later, shows that the veins over dorsum of left hand have returned to normal. (Fig. 56).

Comment:

The onset of symptoms due to glomus tumours often occurs during pregnancy. This fact was mentioned by Greig (1928) and a description of such a case was produced by him. Haemorrhage from tumour is not a common symptom, but occurs in presence of infection and ulceration of surface. The venous dilatation on dorsum left hand disappeared slowly but was completely absent 3 years after operation.

Fig. 61 H & E X 12

Glomus tumour of index finger Left Hand (Case 2) under small magnification. Note ulceration of skin on surface of tumour. Large vascular spaces can be seen in the tumour. A large pacinian corpuscle is present in deeper layer of corium.

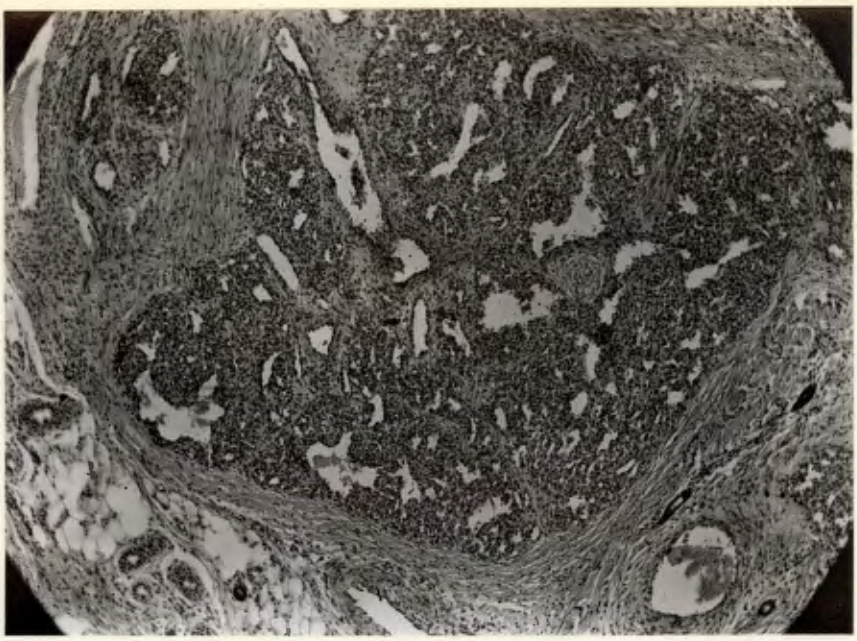


Fig. 62 H & E X 60

Higher power to show glomus tumour (Case 2) and glomus bodies below and to the left.

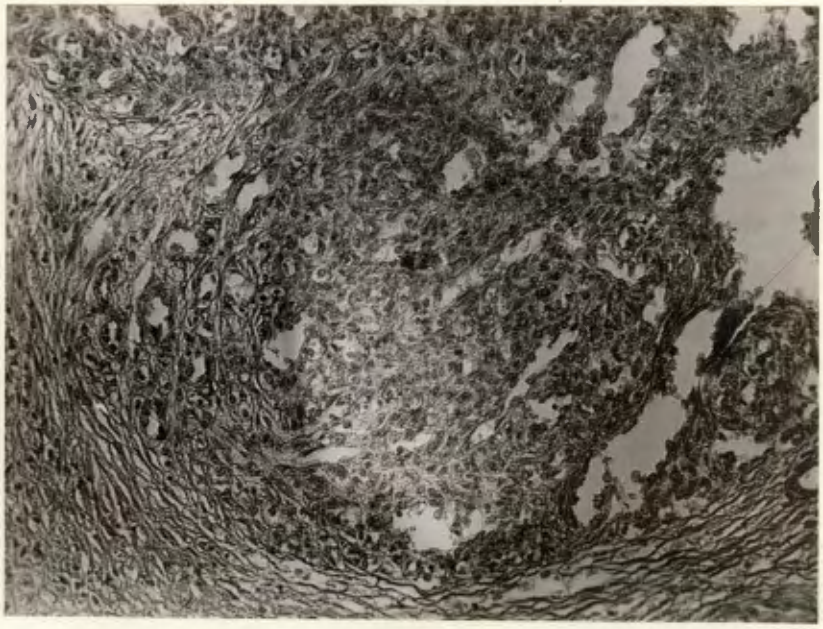


Fig. 63 H & E X 150

High power of same tumour showing several vascular spaces surrounded by typical epithelioid cells.

CASE 3.

November 1946

J.S. Aged 86 years. European Male

Complaint: Painful swelling upper end of left femur - duration 12 years.

Occupation-----Farmer

HISTORY :

Twelve years ago he noticed a small pigmented area over the upper and outer aspect of his left thigh. It was not painful and was thought to be a mole. It did not cause him any discomfort but gradually increased in size.

Five years ago he experienced pain in the lump for the first time. Pain was of a stabbing nature, but could be tolerated by patient and was not present continuously.

During the past six months, the pain has increased markedly, is of a burning nature and is aggravated by even the lightest touch. He cannot bear contact with his clothing nor the blankets when he sleeps at night. There is no radiation of the pain which becomes aggravated during the cold weather. The swelling has recently increased more rapidly in size until admission to hospital when it was about the size of an acorn. As it was very tense and shiny,

Fig. 64

Papillomatous type of Glomus Tumour on the Right Forearm resembling tumour described in Case 3 (After A.P.Stout 1935)

Fig. 65

Epithelioma on Patient's Leg (Case 3) which was present 7 years previously. Note the dilated veins on leg and thigh.

patient sought medical aid as he was afraid that the tumour may rupture.

Previous History:

Forty years ago he had a cauliflower tumour removed from his tongue by means of a cautery. There has been no further recurrence.

Seventeen years ago, he sustained a compression injury to his left thigh when he was pinned underneath a lorry. He remained in bed for several months.

On 15. 6. 40 he was a patient at Groote Schuur Hospital suffering from a swelling over upper end left fibula. The history from previous notes was as follows:-

He had persistent irritation of skin in region of head of Left Fibula, 6 months previously. He then developed a tumour which increased fairly rapidly in size to that of a naartjie. The swelling broke down on the surface and discharged blood-stained material. The lump caused him no pain nor discomfort and did not resemble the present lump. Ruddy complexion. B/P. 170/85. Arteries whipcord in character. Locally, a pedunculated tumour the size of a small mushroom and shaped similarly, situated over head of left fibula. (Fig. 65). The surface had broken down with haemorrhagic discharge. There was a peculiar fleshy smell. The tumour was of rubbery consistency, surface lobulated and edges well defined. It was not attached to head of fibula. The tumour was

excised under general anaesthesia.

The Pathologist's report read as follows:-

"The tumour is mostly papillomatous in structure, but in its deeper parts there is considerable irregularity of growth with invasion of pedicle by squamous Epithelioma"

For many years he has suffered from Asthma, but states emphatically that he has noticed marked amelioration of his symptoms since his operation for the tumour on his Thigh.

FAMILY HISTORY:

No history of similar tumours in his family. His only child died of Infleunza.

EXAMINATION:

For a man of 86 years, his general condition is excellent and his mental faculties clear. Mucous membranes well coloured. Patient is edentulous. No evidence of scars or ulcers on his tongue. Slight dermatitis and scaling of skin of face most marked over malar region. Pupils equal and react to light.
Radial arteries thickened.
Pulse 72 per minute. Irregular rhythm.

Heart: No clinical enlargement. Sounds distant. Irregular rhythm due to extra-systoles. No murmur audible.

Abdomen: Normal.

Chest: Emphysematous chest with diffuse Rhonci and Rales over both lung fields.

C.N.S: Senile tremor. Nil else of note.

Local Examination: Left Thigh is 2 inches shorter than right limb when measured from anterior superior iliac spine to lower border of patella. A scar 3 inches long and ½ inch broad is situated vertically below Greater Trochanter of left thigh. There is absence of dilated veins in region of left thigh and a mild degree of Varicose Veins of left leg exists. Scar has healthy appearance and is not tender. Pulsation of bo th posterior tibials and dorsalis pedis arteries are present. Patient walks with a limp on account of shortening of left leg.

After consultation with Surgeon who removed the swelling, I got the following information:-

There was a swelling the size of a marble situated over lateral aspect upper 1/3rd of left thigh, just below the greater trochanter of the femur. It was bluish-black in colour with absence of any pulsation. It was a spherical sessile growth with a broad base, the diameter of a threepenny piece. (cf Fig. 64). Seven-eighths of the tumour was situated above surface of skin. It was a spongy consistency and attached to overlying skin but not to muscles or deep fascia.

The lump was exquisitely tender, the patient resenting even the lightest touch.

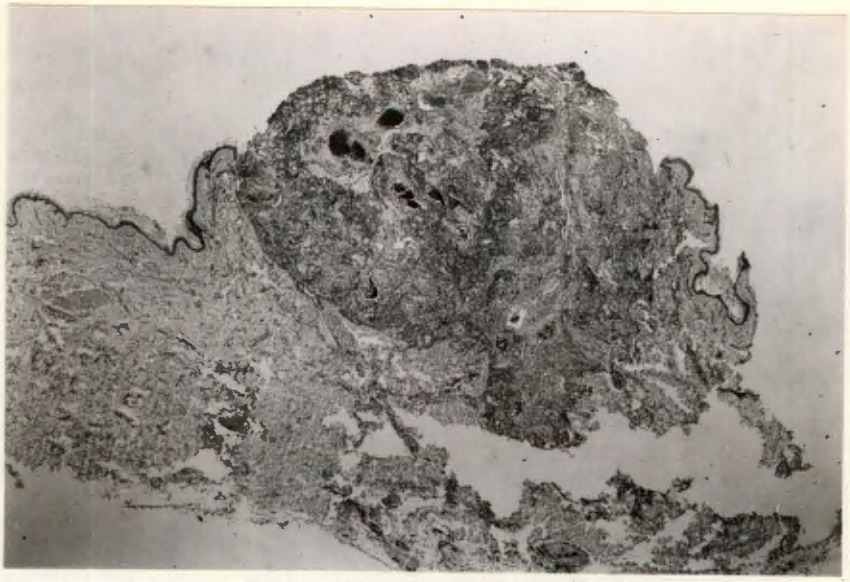


Fig. 66 H & E 12

Low power of Glomus Tumour of thigh. (Case 3). The Tumour is well-defined but shows destruction of overlying skin.

Fig. 67 H & E X 60

Higher power showing edge of same tumour with absence of normal glomus bodies in surrounding connective tissue.

X-RAY OF HEART 11.11.46: Shows bootshaped heart with marked enlargement of left ventricle. The aortic arch is considerably dilated.

X-RAY OF BONES: A large dense mass is evident on inferior aspect of neck of left femur. There is no evidence of destruction of bone. Rest of femur is normal.

OPERATION 19.11.46 under local anaesthesia, an elliptical incision was made starting below the greater trochanter and extending vertically for 3 inches to include the tumour. The tumour was encapsulated and did not involve deeper structures. It measured 6 x 7 mm. There was no excessive bleeding and interrupted silkworm sutures were used for the skin.

Patient made an uneventful recovery and was discharged from hospital a few days later.

MICROSCOPIC STUDY:

Figure 68 shows a very cellular tumour composed of characteristic epithelioid cells. These cells are arranged around vessels, some containing red blood corpuscles. In parts of the tumour the cells are compactly arranged while in others they are scattered diffusely by a large amount of intercellular connective tissue, which shows degenerative or hyaline changes. Not only are there numerous vascular spaces but also many thickwalled vessels in the tumour. The latter does not show presence of a well-marked capsule as was

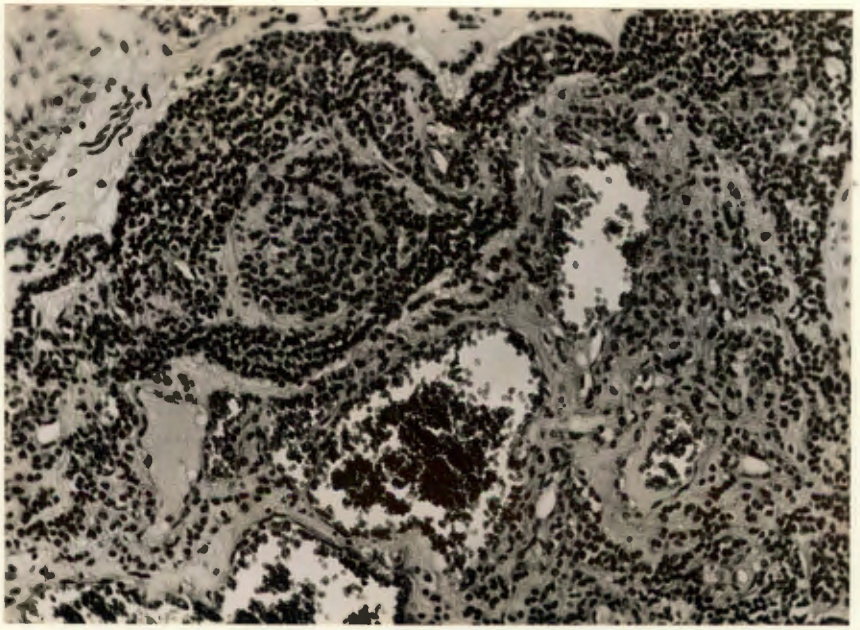


Fig. 68 H & E X 95

High power of Tumour Case 3 showing typical glomus cells which are arranged around vascular spaces. A fair amount of hyaline degeneration of intercellular tissue is present.

shown in the Tumour of Case 1. (Fig. 66). It is surrounded by loose connective tissue containing several large nerves. There was no evidence of normal glomus structures in the specimen. A careful search was made for them. (Fig. 67).

PROGRESS: Patient had immediate relief of pain following the operation. When examined two and eight months later respectively his symptoms were still absent. His asthma, am mentioned earlier on, has not recurred.

COMMENT:

It is interesting to note that in addition to a glomus tumour, a papilloma of tongue and squamous epithelioma of leg occurred in the same patient. The evidence of more than one type of skin tumour in the same patient was recorded by C.F. Geschickter (1936). This feature is also borne out in Case 1.

The patient states emphatically that his asthma cleared up after excision of tumour. This may be explained by the removal of the arterio-venous anastomosis, which, by virtue of its anastomotic channel, conveyed an extra amount of blood to the heart. When we consider Pouiselle's Law, we realise how large a volume of blood can flow through an arterio venous anastomosis when fully dilated. In an already enlarged heart as demonstrated radiologically, this extra burden could cause signs of cardiac decompensation and asthma.

In Fig. 65 we notice the dilated veins on patient's leg and thigh. The history suggests that the glomus tumour and not the epithelioma was the cause of this dilatation, the reason being that the latter tumour has a poor blood supply and is not usually associated with venous dilatation. The glomus tumour must have been present at same time as the epithelioma, judging from the length of history. Also, the removal of glomus tumour lead to the disappearance of veins on patient's left leg. Therefore it is reasonable to assume that the venous dilatation was caused by the glomus tumour.

The shortening of left limb on the basis of an arterio-venous anastomosis, would be difficult to explain. The radiogram of left hip showing excessive bone formation, suggests, however, that this shortening is due to an injury sustained earlier on.

The pain experienced by the patient when undergoing the operation, suggests the ineffectiveness of local anaesthesia for these conditions. (Greig 1928).

CASE 4.

14th March, 1944.

S.W. Aged 18 years European Female

Complaint: She complained of a painful skin area on palm of left hand, duration 15 years

Occupation ----------Schoolgirl

HISTORY:

Ever since she could remember, she has had a tender pigmented area on ulnar side of palm of left hand. When first noticed, it was about the size of a sixpence , circular and resembled a skin bruise. It did not cause her any inconvenience except when pressure was applied to the palm. She would then complain of a burning pain which would persist for a short while. Pain would also be precipitated by cold and relieved by heat. The tumour gradually increased in size to that of a shilling up to time when she reported to the hospital.

A month previously, she injured her left hand after which the pain became more severe. The pain came on more frequently and was precipitated by light touch and by dependency of the hand. In order to prevent this she held her hand in a characteristic attitude by placing it close to her face. Pain was not aggravated by

emotional upsets. During an attack of pain, the affected part assumed a mauve colour and small vessels would be visible on the surface. The pain radiated to the tip of the little finger making her whole hand feel weak.

The palm of her left hand always felt moist. During an attack of pain, the sweating of the hand would increase.

On the 14th March, 1944, she reported to Woodstock Hospital where the diagnosis of a glomus tumour was made. At operation, using local anaesthesia, an area of surrounding skin with the tumour was removed.

She was examined by me on 11.4.47, three years later. She had been completely free from pain and did not have any local recurrence. Her general condition was excellent and there was no evidence of any cardio-vascular involvement.

Locally, a scar of previous operation was present (Fig. 69). It was about 1 inch long and situated along ulnar border of left hand in line with distal palmar crease. The scar was not tender.

There was absence of increased sweating of the left hand and no evidence of dilated veins on the dorsal surface.

On closer inspection, the left little finger appeared longer than on the right hand and on measurement

Fig. 69

Case 4. Note scar at site where tumour was removed from left hand. The nail of 5th finger is longer than the opposite side.

R. Fig. 70 L.

Radiogram of same case showing increased growth of 5th metacarpal bone of left hand.

the difference was found to be ½ cm. centimetre. The nail of the left little finger was kept long and appeared very brittle. According to her statement she refused to cut it as the growth of the nail was interfered with since her operation. It would not grow beyond length shown inthe picture, even though it was not cut for one year.

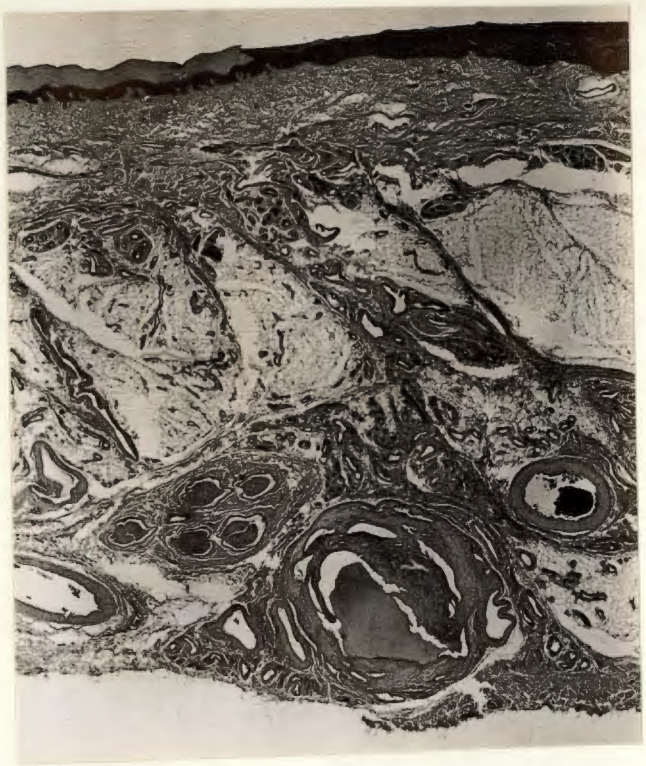
There was diminished pain sensation of skin on flexor surface of little finger as determined by pin prick.

X-Ray of Hands (Fig. 70).

No abnormal calcification of metacarpal bones and phalanges were seen. The 5th finger of the left hand appeared longer than the right hand. The difference in lengths of the two digits were due to increased growth of the 5th left metacarpal.

Measurements in millimetres:

Bone	Left Hand	Right Hand
Metacarpal 5th finger	51	50
Proximal Phalanx 5th finger	30	30
Middle phalanx 5th finger	17.5	17. 5
Terminal phalanx 5th finger	15	15
Metacarpal 4th finger	55	55
Metacarpal 3rd finger	62	62



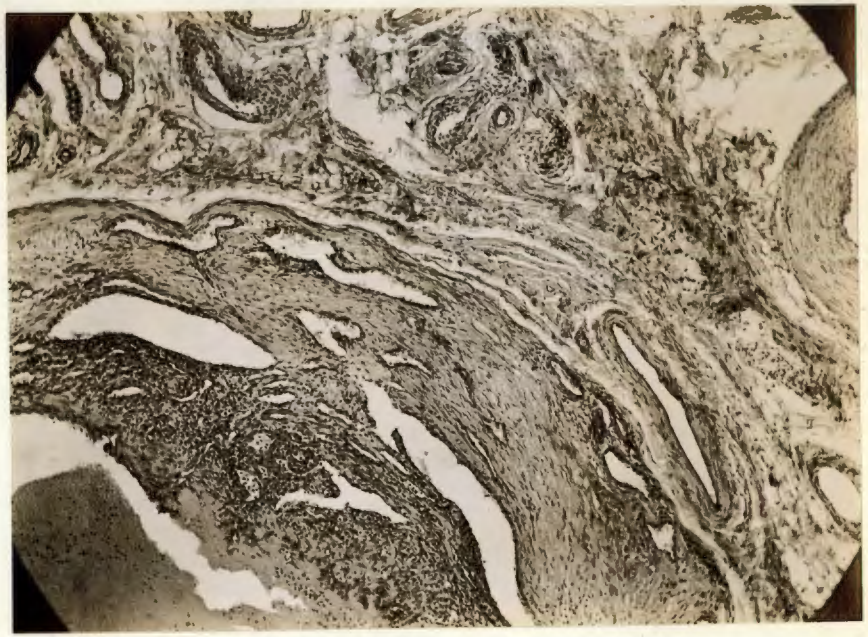


Fig. 71 H & E X 12

This is a small tumour situated in deeper portion of the corium. The tumour shows a well-defined capsule and clumps of glomus cells are separated by large vascular spaces.

Note the large vessels & nerves in neighbouring tissue. (Case 4)

Fig.72 H & E X 60

High power of upper right portion of same tumour. Note the typical dark staining muscle of glomus cells of Tumour. In surrounding connective tissue several normal glomus bodies are visible. By comparing their appearance with that of the tumour a strong resemblance is noticeable.

MICROSCOPY (Figs. 71, 72 & 73).

A tumour, measuring 2 x 2 mm. is situated in the deeper portion of the dermis. It is surrounded by a well defined capsule containing a few vessels.

The glomus cells are most obvious on right side of tumour where they are closely packed around small vascular spaces. The middle of the tumour consists of a large space containing red blood corpuscles. In the rest of the field, these epithelioid or glomus cells are not so numerous.

Large, thick walled vessels from which the afferent artery arises, surrounds the tumour.

Above and to the left of tumour a large nerve bundle has been cut transversely.

Several normal glomus bodies were detected in the surrounding tissue. (Fig. 72). The resemblance of the cells of these bodies to that of the glomus tumour is readily seen.

Several pacinian corpuscles and numerous sweat glands are visible in the reticular portion of the dermis.

COMMENT: The increased growth of bone as seen in the 5th metacarpal of affected hand resembles the features detected in congenital arteriovenous anastomosis. (Case 9).

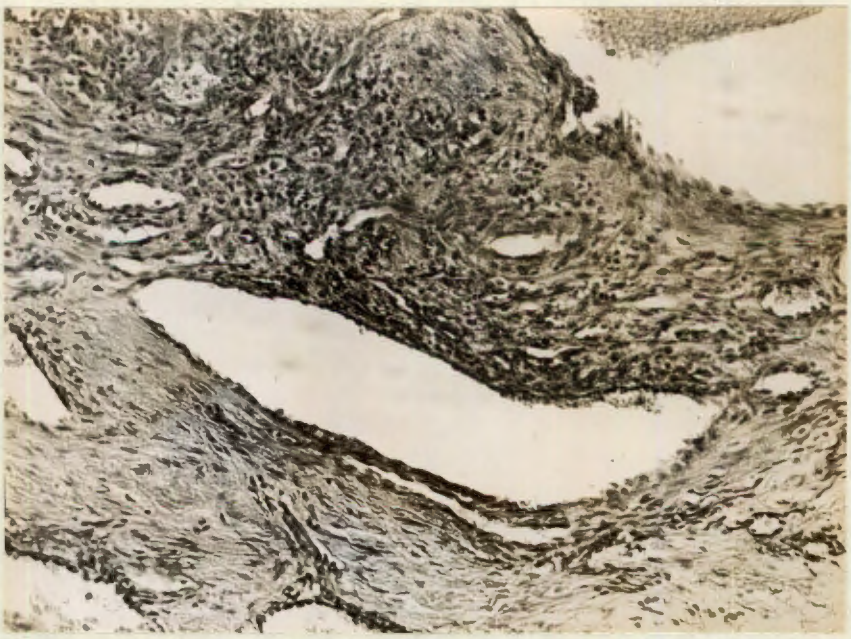


Fig. 73 H & E X 150

High power of tumour (Case 4). The typical Glomus cells with clear cytoplasm and dark round nuclei are clearly demonstrated.

CASE 5

J.H. Aged 25 years Coloured Female

Occupation:----Domestic Servant

Complaint: Painful right index finger, duration 13 years.

HISTORY:

Since the age of twelve, she has been complaining of a painful right index finger. There was no history of trauma at time of onset. The pain gradually increased in severity and was of intense burning nature. She consulted several doctors without relief of symptoms and had her finger nail removed on one occasion. Recently, she has noticed a small swelling under the edge of the nail. It had a bluish colour and was extremely tender even on lightest touch. The nail was elevated off the nail-bed and curved inwards at its extremity. (Fig. 74).

On 13. 6. 39 she visited Groote Schuur Hospital where a diagnosis of subungual exostosis was made. The X-ray, however, did not reveal such pathology.

Under local anaesthesia, the finger nail was removed and revealed a small swelling the size of an orange pip. It had a distinct purple colour

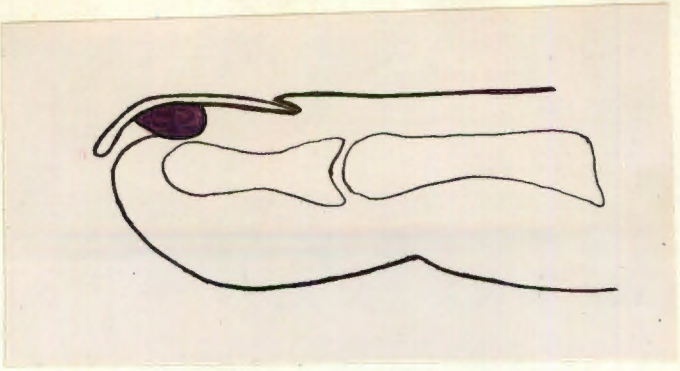


Fig. 74.

A diagrammatic reproduction of subungual glomus tumour of Case 5 taken from available drawings. Note the elevation of nail off the nailbed and the incurving of the nail.

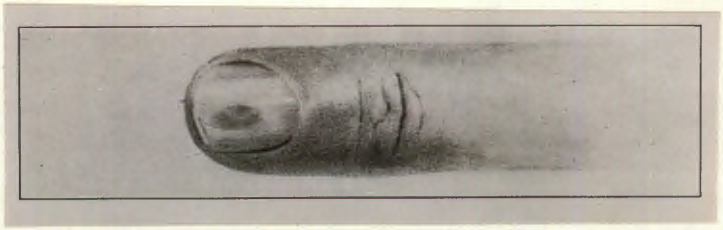


Fig. 75

After Bailey (1935). Drawing of a subungual glomus tumour. There is no elevation or erosion of nail.

and was pedunculated. A diagnosis of papilloma was made and a snip taken for section.

Professor Ryrie's report read as follows:-

"The histology is that of a glomus tumour".

On 1. 8. 39 the tumour was excised under local anaesthesia making a wedgeshaped incision and taking away part of the terminal nail-bed.

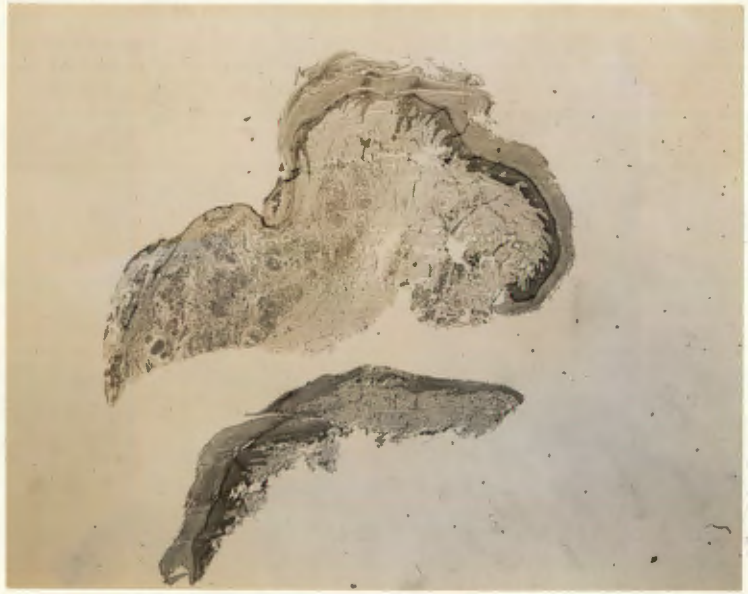
The patient still complained of severe pain in the finger and on 5.8.39 the tip of the finger was amputated.

The histological picture again confirmed the presence of a glomus tumour.

Since her operation she has been completely free from her pain. Unfortunately, a follow up of this case was not done on account of the patient's death during childbirth in 1946.

MICROSCOPIC STUDY of the slide (Figs. 76 & 77) revealed the following:-

The tumour measured approximately 5 x 3 millimetres. Numerous epithelioid cells with darkly staining nuclei are present in the nail bed. These cell s are not closely packed on account of numerous small vascular spaces separated by delicate collagenous tissue. A notable feature of this tumour, is the absence of a



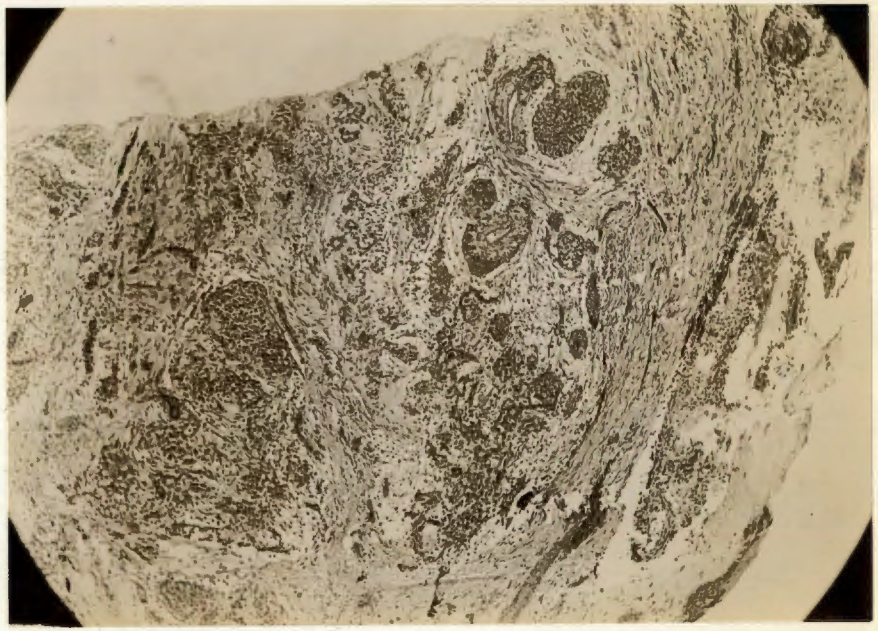


Fig. 76 H & E X 12

The uppermost picture shows both nailbed and pulp. The latter can be recognised by the thickened squamous epithelium. A distinct bulge on surface of pulp is visible beyond nailbed. The tumour is not encapsulated and is recognised by aggregrations of darkly staining cells which are most numerous in nailbed but extend to the pulp.

Fig. 77 H & E X 60

A high power of same case showing the tumour cells on left hand side of picture and presence of normal glomus bodies on right hand side. Note the similarity of the cells. There are very few vascular spaces present in the tumour.

capsule. The tumour invades portion of the pulp which is in close proximity to the nail bed. In the latter situation, the cells are separated from the surface epithelium, by a thin layer of connective tissue.

Comment:

This case illustrates the importance of being able to recognise the tumour in order to administer the correct treatment.

This patient endured years of suffering and had 3 operations performed on her finger. The third time she had an amputation of the phalanx performed as a wedge resection of nail-bed did not prove efficacious. This goes to prove that in order to relieve the pain, the whole tumour has to be removed.

CASE 6

April, 1940

E.L. Aged 58 years. European Male

Occupation ------Railwaymen

Complaint: Painful swelling on right wrist,
- duration 5 years -

HISTORY :

About five years previously he had noticed a small swelling on ulnar border of his right wrist, which did not cause him any discomfort. It gradually increased in size to that of a walnut and became very painful. He did not remember ever injuring his right arm. The pain was of a burning nature over the tumour. At times he would experience sudden stabbing pains in the right wrist. In the patient's own words, he states:- "All I can say is that it was very painful. So much so, that I could not allow the sleeve of my jacket to touch it and had to hold it away. The doctor told me it was a tumour in the nerve centre".

There was no discolouration of the skin over the tumour but noticed that the veins on dorsum of right hand were very prominent. He did not complain of increased

Fig. 78 H & E X 12

Large glomus tumour removed from the wrist (Case 6). Note the close arrangement of cells with few vascular spaces. Tumour is encapsulated. In upper middle portion of tumour a large vessel divides it into two portions. This is the afferent artery of the tumour.

sweating of his hand. There were no other swellings on his body.

On 23. 4. 40 the tumour was removed under local anaesthesia at the Rondebosch hospital. Since then he has been completely free from pain.

The preoperative diagnosis was that of a fibroma or ganglion on the wrist.

Prof. Ryrie's report on the pathology read as follows:-

> "The lesion is not a fibroma. It is a soft cellular tumour consisting of uniform cells of epithelioid type. These show no evidence of active growth. The structure corresponds to that of the glomus tumours of vascular origin. The tumour is not malignant".

MICROSCOPIC STUDY OF TUMOUR: (Figs. 78,79 & 80)

This tumour after operation measured 1½ x 1 cms. It is a very cellular tumour surrounded by a well defined capsule. A large artery divides the tumour into two unequal portions. The lumen of the vessel is visible for part of its course after which the section traverses its thick muscular wall. This is the afferent vessel to the tumour.

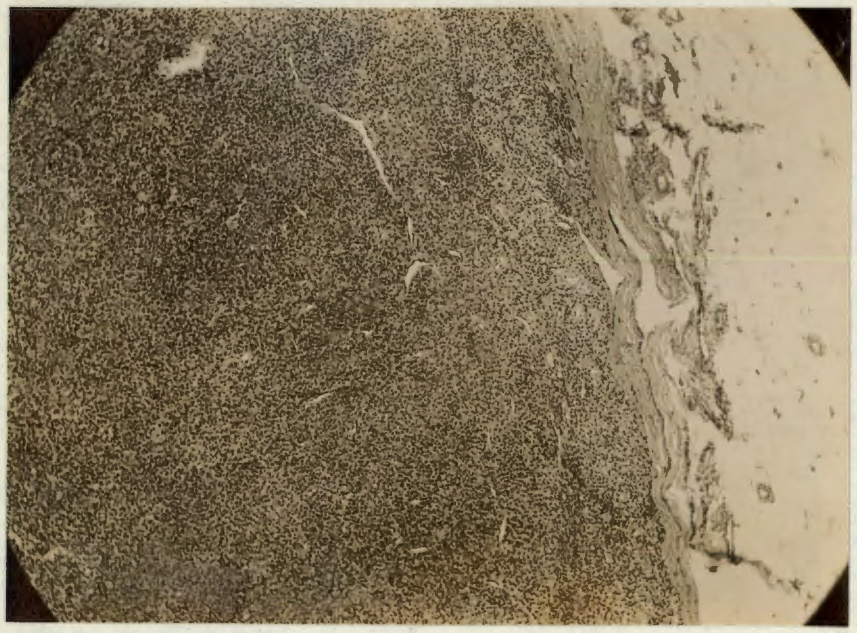


Fig. 79 H & E X 80

Case 6 showing closely packed Glomus Cells. Microscopy strongly resembles that of Case 1. See Fig. 52.

Fig. 80 H & E X 95

The same tumour with higher magnification. Note the afferent artery with typical muscle cells with spindle-shaped nuclei in contrast to rounded nuclei of glomus cells.

The cells have deeply staining nuclei and are very closely knitted together. There are few vascular spaces separating the cells masses. This tumour in many respects strongly resembles the tumour of Case 1 (Fig. 52).

Very few nerve bundles are present and no normal glomus bodies were seen in the surrounding tissue.

CASE 7

27th January, 1940.

E.P. Aged 66 years European Male

Above patient was admitted to hospital for retention of urine with overdistension of bladder. On radiological investigation, he was found to have a bilateral congenital megalo-ureter and hydronephrosis.

On admission, a small soft bluish tumour, about ⅞ inch in circumference was noticed in front of the region of the tibial tuberosity.

This swelling had been present since 1905 approximately thirty five years. He first noticed it when getting up from bed after a cold. It was then the size of a pea and was unassociated with trauma.

He experienced pain from the time of onset of the tumour. Pain was of very intense nature, with complete absence of radiation. Pain was brought on by even the lightest touch, consequently the patient developed little protective tricks, such as putting his hand in his righthand pocket, to keep his overcoat from flapping against the tumour. He also had to discard his stiff leather leggings.

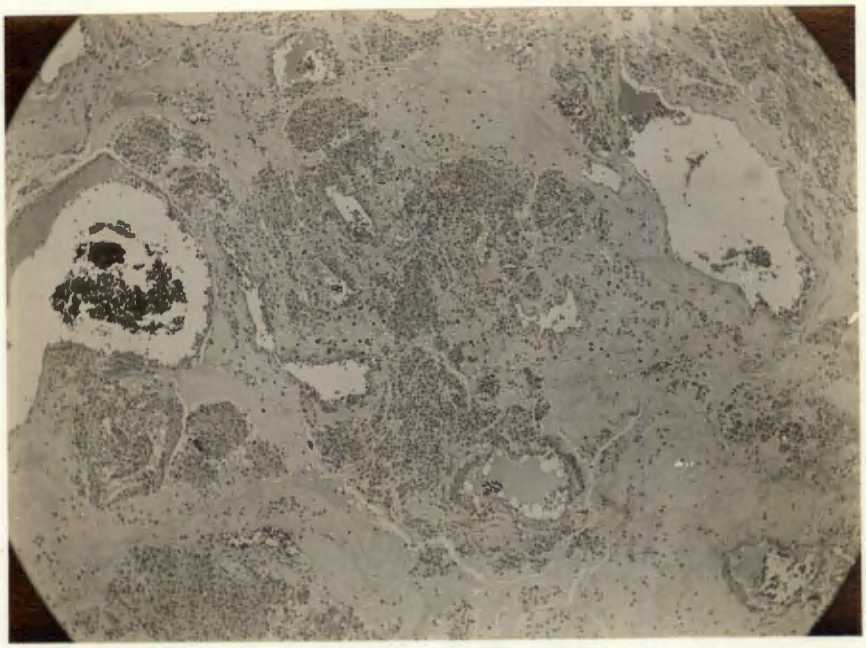


Fig. 81 H & E X 60

Glomus Cells arranged in small aggregations with hyaline degeneration of portions of connective tissue stroma. Note the large vascular spaces.

The "Trigger" Spot, if touched suddenly released a violent series of painful stimuli sometimes lasting 30-40 seconds.

The tumour was more uncomfortable when warm and when the patient was sitting before a fire. Cold did not affect it.

The patient, who had a serious urological disease, considers that the removal of the glomangioma alone justifies his admission to hospital. Since it was first noticed, the tumour has become larger, bluer and more painful.

At operation the tumour was readily enucleated. In spite of the vascularity of the tumour, no definite pedicle was seen, although a small strand of tissue containing blood vessels was ligated.

Pathological Report:

The tumour is a glomangioma. The section shows the thin walled blood vessels surrounded by masses of glomus cells. (Fig. 81).

Comment: It is interesting to note that pain was brought on by Heat and not cold, thus resembling Case 8.

I am indebted to Mr Currie for allowing me to publish this case.

CASE 8

26. 10. 1943

M. C. Aged 48. Coloured Female

Occupation---Housewife

Complaint: Painful swelling of left hand -duration 3 years -

HISTORY:

Three years ago she noticed a small firm nodule, slightly bigger than a pin's head on medial side of her left hand. It was of whitish colour and did not cause her any discomfort. She did not attribute this to any trauma. A few months later it became tender to the touch and as time progressed it very slowly increased in size.

One year after onset she experienced sudden sharp pains in the tumour. She consulted several doctors who prescribed various ointments including some local freezing ointment which did not alleviate the pain.

The attacks of pain came on in paroxysms and was of a burning nature. It radiated along ulnar aspect of left limb and sometimes reached as far as her left breast. The pain came on very suddenly, lasted a few seconds,

and passed off again until initiated by one of the following factors:-

When hands were immersed in hot water, when working near an oven, and when brushing hand against her clothes. This caused the patient to adopt a protective attitude which would avoid contact with any objects.

She is confirmed that a change in weather would precipitate an attack. She states assuredly, that immersion of hands in cold water did not bring on an attack of pain. Lately she had been sleeping badly as the pain would wake her causing her to take sleeping drugs.

She noticed that since onset of pain, the swelling had changed to a blue colour. It was now slightly smaller than a pea.

She did not notice increased sweating of left palm but was definite that left hand always felt warmer than the right. She noticed that the dilated veins on dorsum of her left hand, had subsided since removal of lump on her hand.

Previous History:

She had never had other lumps on her body except for small lump on side of her face which had been present since childhood. No history of trauma.

At 18 years of age, she crushed ring finger Left hand, requiring amputation of finger. No other illnesses of note.

Family History

Five children who are all well. Her Husband

died two years previously from enlarged liver, the cause of which was unknown.

Examination:

Well nourished, healthy female with no evidence of cardiac pathology.

Locally, an operation scar one inch long was situated over ulnar border of left palm, just below distal flexor crease.

There was complete absence of tenderness over this area.

The veins on dorsum of her left hand were not dilated and there was no increase of digital growth when the two hands were examined.

Histological report by Profeesor Ryrie:

"The structure is that of a Glomus Tumour"

I was unable to obtain the histological sections of this case.

PART 111

A. ALLIED CONDITIONS

A description of the glomus bodies would not be complete without reference to certain closely allied conditions. These include the following:-
Glomus coccygeum, congenital arterio-venous anastomoses and leiomyoma.

THE GLOMUS COCCYGEUM

This is also known as the coccygeal body or Luschka's Gland.

The glomus coccygeum has been observed as early as the 52nd day of intra-uterine life. It is a small reddish-yellow ovoid body which lies embedded in areolar tissue in front of the tip of the coccyx but sometimes below it. According to Walker, the surest guide to the body is the middle sacral artery, to whose anterior surface the little organ is attached, its long axis lying transversely to that of the blood vessel. This vessel is the artery of supply to the glomus, where it breaks up into smaller branches which eventually supplies the cell masses.

The dimensions are small measuring 2 x 3 x 2 millimetres and is sometimes divided into two or more tiny bodies.

HISTOLOGICAL STRUCTURE (Fig. 92)

As seen in transverse section, numerous aggregations of epitheloid cells embedded in connective tissue are visible. Sometimes a thick-walled artery is detected in the field. The proportion of cells masses to the connective tissue stroma varies, the latter usually being present in excess.

Each aggregation of cells contains a central blood space, limited by an endothelial wall similar to that of a capillary. Against this wall the epitheloid cells lie without intervention of connective tissue. These cells are closely packed, presenting a polygonal contour. The cells form 2 - 5 layers, each cell being indistinctly outlined and composed of a clear cytoplasm containing a darkly-staining nucleus. The whole gland is surrounded by a capsule of loose connective tissue.

There has been a great deal of dispute concerning the innervation of the gland. Walker, Von Schumacher and Stoerck oppose the views that a rich somatic or sympathetic nerve supply exists. The absence of chromaffin cells in the gland was also demonstrated by them. Masson (1937) maintains that the loose connective tissue zone is extraordinarily rich in nerve fibres.

The function of the gland is as yet

Fig. 92

Glomus coccygeum (after Masson 1937)

Several anastomotic channels are visible. Some have been sectioned longitudinally whilst others have been cut transversely. Note that the wall of the channel is composed of typical glomus cells. The clear zone around the glomus consists of nerve tissue. The darker staining portion on periphery represents part of the capsule.

unknown. In text-books of anatomy (Gray's, Piersols, Quain's) they are described under the ductless glands. They should more correctly be classified under arterio-venous anastomoses, in which case they could act as large vascular shunts.

SOLITARY CUTANEOUS LEIOMYOMA

History: The first painful leiomyoma was removed from a finger of a poet and was described by Axel Key (1873). Babes (1885) made a summary of whole subject and classified them according to their sites of origin.

Up to 1937, only 3 cases have been described in English literature. Wassenaar (1931) in South African Medical Journal described a tumour on the eyelid arising from Muller's muscle.

In all, 85 cases have been described in the literature up to 1937.

Definition: The leiomyoma is a benign tumour derived from plain muscle in the skin.

Some authors divide them into 2 types: (1) Multiple cutaneous myomata (2) subcutaneous leiomyomata according to site and structures from which they are derived. (MacLeod 1920 and Gaskill 1923).

The former are derived chiefly from arrector pili muscles and the latter from muscle of blood vessels, scrotum and labia majorum.

The single subcutaneous or cutaneous leiomyoma concerns one most on account of their strong resemblance to glomus tumours.

Site of Tumour

The majority occur in the lower limbs on the extensor surface. The genital zones, viz: nipple, areola, scrotum, penis and labium majus are common situations.

Source of Muscle (Stout 1937)

1. Arrectores pilorum, sweat gland muscle and blood vessels. (Figs. 93, 95).
2. Muscularis sexualis, e.g. in skin of scrotum, penis and labium majus, nipple and areola,
3. Skin of axilla and anal region.
4. Irregular sites, e.g. cheeks, scalp and forehead.

Clinical Features

The age and sex groups are equally affected. There is no racial discrimination.

Symptoms

The most significant symptom is pain. It may occur spontaneously without a known cause, awakening patient in middle of night, or it may be initiated by exposure to cold,

mental disturbance, exercise, fatigue, indigestion, menstruation, pregnancy or even the lightest touch as from pressure of clothing, (cf. glomus tumour).

The paroxysms last for a few minutes to half an hour.

The pain may be lightning, stabbing, burning or colicky in nature. In connection with last-named symptom, Stout (1937) (Case X) records a tumour in the groin giving rise to cramplike pains with a desire to go to stool. This feature is analagous to excessive peristalsis with colicky pain in hollow muscular systems.

The most arresting feature is the non-radiation of pain (Stout 1937).

Signs

The tumours are generally small, measuring 2-15 millimetres in diameter. They are rounded, forming a nodule which elevates the skin (Fig. 99) but may be imperceptible if small. The consistency is that of hard rubber. The tumours are freely movable and encapsulated.

The more superficial tumours produce a discolouration of overlying skin, but this feature is absent when tumour is situated deeply. They are very tender but not to same degree as the glomus tumour. A most interesting sign is the contraction of the tumour during an attack

of pain. This was found by Hagiwara and Sugizaki (1933), who showed that an injection of adrenalin would increase the pain.

One observer found that wormlike contractions occurred in the tumour removed from labium majus even after removal from the body (Stout) (1937).

Course:

The growth ceases afte r a time, but the pain becomes progressive. Seven cases are reported to have undergone malignant changes.

Microscopy

Two types have been described.

(a) Vascular tumours - Case 10 offers a good example of this type (Fig. 95)

(b) Non-Vascular Tumours (Fig. 100)

This tumour is derived from skin muscles. They show smooth muscle cells only without presence of vascular lumen. They are not encapsulated and do not grow to a large size. Some authors imply that these tumours are malignant and show mitoses.

The presence of nerves in these tumours is still under dispute and has not been finalised.

Treatment

Excision of the tumour leads to complete cure.

CONGENITAL ARTERIO-VENOUS ANASTOMOSIS

Excellent accounts have been published on the above condition by Dean Lewis (1930) and Pemberton and Saint (1928). A few features will be mentioned in order to bring out the salient points in the relationship to the glomus tumour.

Local Signs:

(a) Marked dilatation of veins occurs in affected part. Visible pulsation of veins may be present and a thrill may be felt.

(b) Hypertrophy of a limb takes place due to increased blood volume.

(c) The temperature of limb is raised.

(d) Trophic changes - This is due to anoxaemia of tissues distal to the fistula as a result of venous stasis.

General Signs:

(a) A low diastolic blood pressure with a raised pulse pressure is sometimes found but is more common in the traumatic arterio-venous anastomoses.

(b) The total blood volume is increased in order to

maintain adequate circulation.

(c) Cardiac enlargement and general signs of decompensation takes place.

(d) The pulse rate is increased.

(e) The volume per cent. of oxygen of blood taken from the veins is considerably raised.

In order to show the relationship of the glomus coccygeum, congenital arterio-venous anastomosis and leiomyoma to the cutaneous glomus and its tumour, certain features have to be recapitulated.

The Glomus Body is composed of vessels, muscle, nerves and glomus cells.

The Glomus Tumour is a neoplasm or hypertrophy of the glomus body.

The Glomus coccygeum consists of vessels, muscle, nerves and glomus cells. It therefore bears the most striking resemblance to the glomus body.

In the congenital arterio-venous anastomosis larger vessels are involved and resemble the glomus body chiefly from the physiological aspect.

The leiomyoma closely resembles the glomus tumour clinically but histologically the plain muscle element preponderates.

In conclusion, reference has to be made to the carotid glomus and aortic glomus bodies. A great deal of confusion has arisen in the literature by applying the term "glomus" to the above structures.

Pierre Masson (1935) states that although the aortic and carotid bodies have a rich vascular and epithelial network, these are the only significant features to justify the term glomus. In the carotid and aortic bodies the epithelial cells of grandular appearance are developed from the sympathetic nervous system and belong to the Chromaffin or paraganglionic series. In the glomus cutaneum and glomus coccygeum these cells are modified contractile cells and are arranged in a different manner.

B. CASE HISTORIES

CASE 9

4th March, 1946.

Mrs M.S. Aged 24 years Malay Female

Occupation ------Housewife

Complaint: She complained of painful right index finger ------ duration six years.

HISTORY:

Six years ago she noticed a small pimple on radial side of right index finger. It was very painful, broke down and developed into an ulcer with a yellowish discharge. There were periods of healing and regression of this ulcer.

Four years ago a piece of wood penetrated her right index finger after which she developed another ulcer distal to the previous one which by now had healed. The ulcer would heal but broke down at different times. In October 1945 she had a large haemorrhage from this finger and lost approximately a cup of blood. On 4th March, 1946, she was admitted to Groote Schuur Hospital in a state of collapse after losing two pints of blood from the ulcer.

Previous to this episode, her finger had been very painful. The pain was most severe shortly

before the haemorrhages. At other times she experienced pain in her finger when receiving gentle knocks. The pain was of a throbbing nature and radiated as far as her wrist. When she immersed her hands in cold water it would precipitate an attack of pain. Attacks were more frequent during cold weather and pain was relieved by heat. Prolonged dependency of right arm and compression of vessels around her wrist, would initiate pain in the right index finger.

Two years ago the finger and associated wrist began to throb. At the same time she noticed a gradual wasting of the finger tip with blueness of whole finger.

She did not experience shortness of breath on exertion and was able to do a full day's house duties.

Previous History: Nil of note.

Family History: She had 4 normal pregnancies. The youngest child was three months old.

Examination: A well-nourished coloured female with a normal pulse-rate.

Heart: There was no clinical enlargement and apex beat was not displaced. A loud blowing systolic murmur was present over the aortic area. The blood pressure in right arm equalled 145/76; and in the

Fig. 82

The larger size of Right hand and increased length of right forearm is evident. Note the pointed right index finger and presence of increased growth of hair on the right hand.
(Case 9 - arteriovenous anastomosis of right arm).

left arm 115/60.

Central Nervous System was not involved with Absent Horner's Syndrome.

On Local Examination the right hand appeared larger than the left and the right index finger was longer than the opposite side. There was increased growth of hair on dorsal surface of right hand and wrist. (Fig. 82).

The veins on dorsum of right hand and thenar eminence were markedly dilated. (Fig. 83 and 84). On lateral side of wrist a coarse thrill was palpable during systole and diastole. A machinery murmur was audible over this area on auscultation. The right hand felt warmer than the left.

The right index finger tapered to a point and showed a small deep ulcer on radial side of proximal interphalangeal joint. The edges were slightly raised and very tender on palpation. A blood stained discharge was present on the surface.

The tip of the index finger appeared purple and atrophic.

Investigations:

Temperature Charts (Fig: 85)

Fig. 83

Fig. 84

Figs. 83 and 84 show markedly enlarged veins on dorsum and thenar eminence of the Right Hand.

The most marked differences of temperatures were recorded.

(a) Over the distal flexor crease of wrist where readings were 36.4 and 33.7 degrees centigrade in right and left hand respectively.

(b) On the dorsal surfaces of wrists where the readings were 32 and 36 degrees centigrade in the left and right hands respectively.

X-Ray of Hands:

The bones of right hand show increased growth compared with the left hand. (Fig. 86)

The differences are most marked in the metacarpals and proximal phalanges of index fingers.

Bone	Right Hand	Left Hand
2nd Metacarpal	66 mm.	59 mm.
Proximal Phalanges	43 mm.	38 mm.

X-Ray Bones of Forearms (Fig. 87).

Above shows unequal lengths of bones of forearm.

Radial Bones:

Measured from tip of styloid to base of bone.

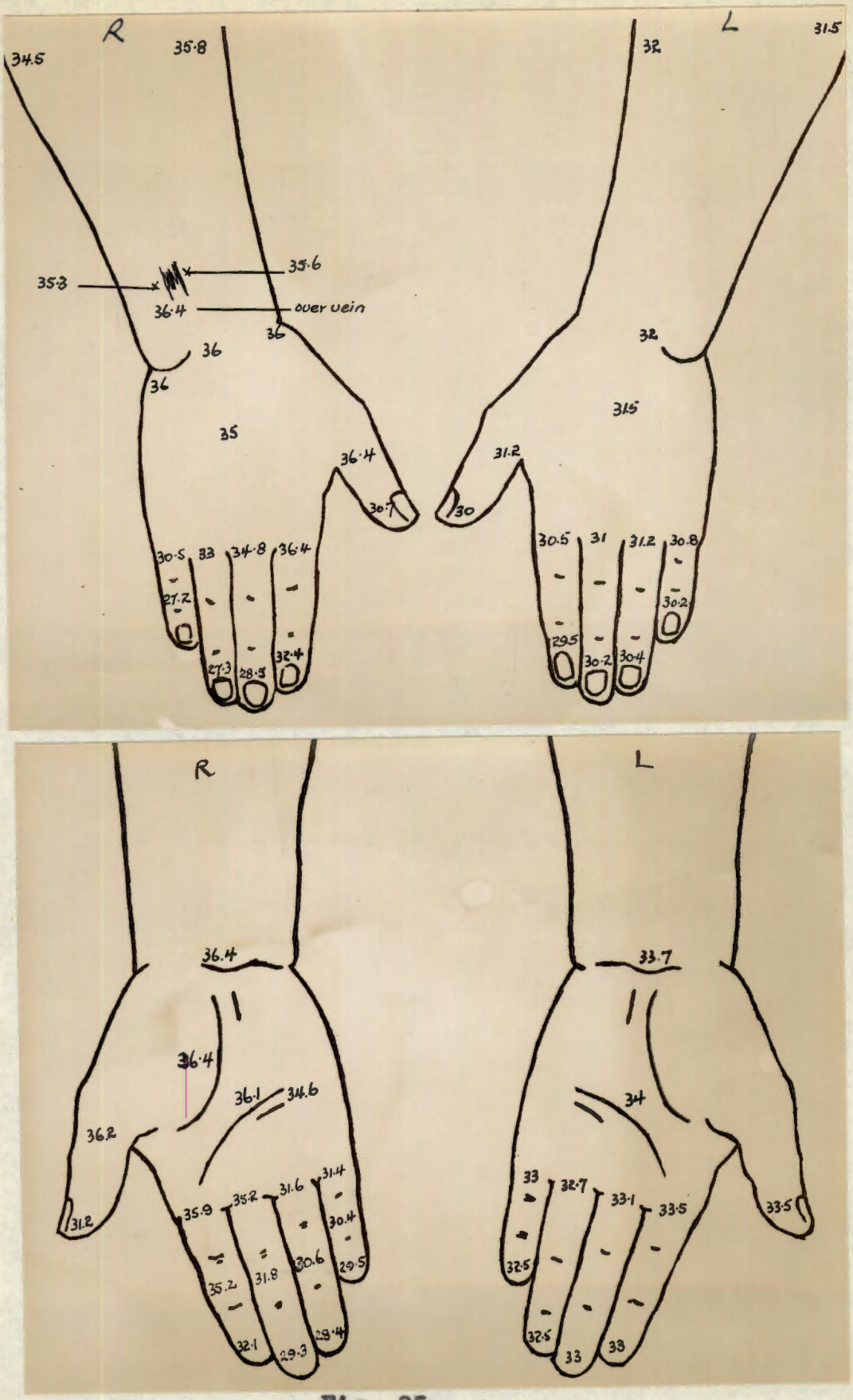


Fig. 85

Temperature charts of both hands.
Note the higher temperature recordings of affected hand. (Right).

Fig. 86

Radiograms of two hands showing increased growth of the Right Hand.

Fig. 87.

This picture shows the longer radius and ulna of right limb Note that metacarpals of the right hand are off the plate.

Right Radius = 9⅜ inches

Left Radius = 9 inches

Ulnar Bones

Measured from tip of styloid process to distal end of olecranon process.

Right ulnar = 10⅛ inches

Left ulnar = 9⅛ inches

Arteriogram (Fig. 88)

This figure shows dilated and tortuous vessels in the 1st and 2nd interosseous spaces. The digital arteries of index finger are markedly coiled. At the site of the ulcer, the digital artery gives off a tuft of dilated arterioles showing as a dense blob on lateral side of head of proximal phalanx. Other smaller tufts can also be seen on the digital arteries.

X-Ray of Heart (Fig. 89)

This shows enlargement of the right ventricle.

Electrocardiogram (Fig.90).

There is nothing gross except tendency towards left axis deviation in lead 1 and slight increase in the heart rate.

Phonocardiogram (Fig. 91)

Taken from thenar eminence (Fig.91a) shows a

Fig.88

Arteriogram showing the enlarged arteries of right hand. Note the size and tortuousity of digital arteries of right index finger. The radial and ulnar arteries in forearm are also enlarged. Small tufts of dilated arterioles show as dense blobs in the vessels

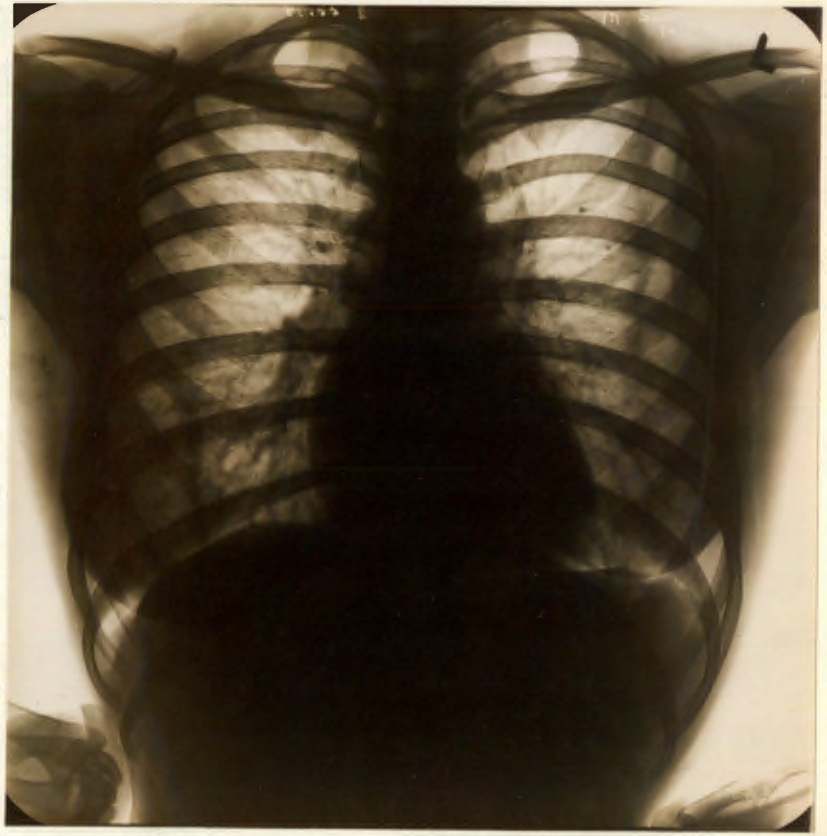


Fig. 89

A cardiogram of Case 9 showing the enlargement of the Right ventricle.

machinery murmur with fewer oscillations than in (Fig 91b). The latter was taken from area over anatomical snuffbox and shows a machinery murmur continuous through systole and diastole .

Oxygen estimations of the blood from mid-dorsal regions of hand

Date	Sample	Room Temp. °C	Right Hand	Left Hand
3.3.47	1	29	17.36	15.14
	2	29	17.53	15.21

COMMENT:

The close relationship of this condition to the glomus tumour is evident, and is best illustrated by the following features:-

1. The marked venous dilatation of the parts.
2. The increased growth of the affected parts
3. The increased temperature recording.
4. Increased oxygen content of venous blood.

Local pain which is usually absent in arteriovenous anastomosis was present in this case. This suggests the possibility of the existence of a glomus tumour at the site of the ulcer and might have

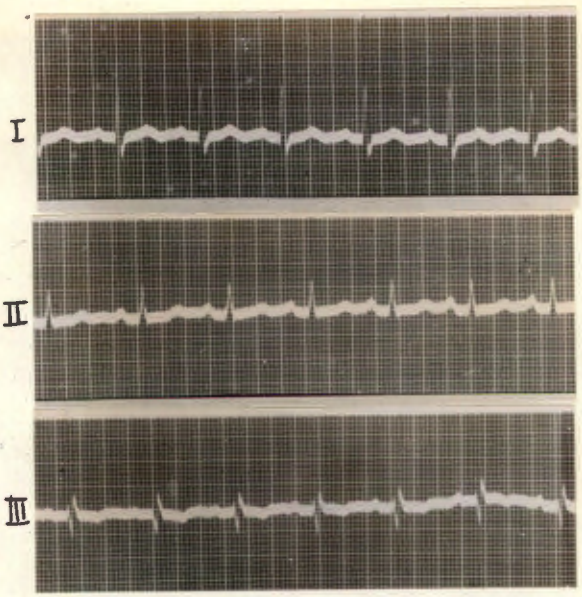


Fig. 90

An electrocardiogram from Case 9 showing a normal tracing.

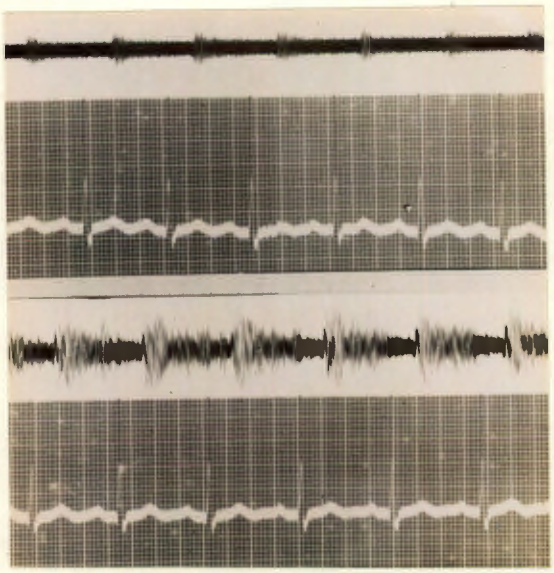


Fig. 91

Typical phonocardiogram of above case showing the continuous character of the murmur. (a) Over thenar eminence (b) Over anatomical snuffbox.

accounted for the severity of the pain. The presence of a small tumour at the onset further suggested this possibility.

The most marked difference between the two conditions is the degree of involvement of the part. Whereas glomus tumour affects one localized area of the digits, congenital arteriovenous anastomosis has a much wider spread and usually affects a portion of a limb. Consequently, the generalised effects produced by the latter are severe as evidenced by cardiac involvement.

CASE 10

K. D. Aged 39 years. Coloured Female

Occupation -------Housewife

Complaint: Painful right leg - duration 4 years

HISTORY:

With her seventh pregnancy 4 years ago, patient experienced a burning pain in her right heel. She could not recall any trauma to her leg. The pain came on in attacks which would last a variable time. Pain increased in severity as she approached full term but completely disappeared after the birth of the child. With each successive pregnancy patient has experienced the same symptoms except that the pain appeared to have changed in position from underside of heel to neighbourhood of tendo-achilles.

Patient is now forty weeks pregnant. The symptoms commenced early in her pregnancy and has gradually increased in severity up to the present. She described the pain as paroxysmal in nature, commencing as a sudden stabbing pain behind the right heel. As pain subsides, she experiences a burning feeling in the leg.

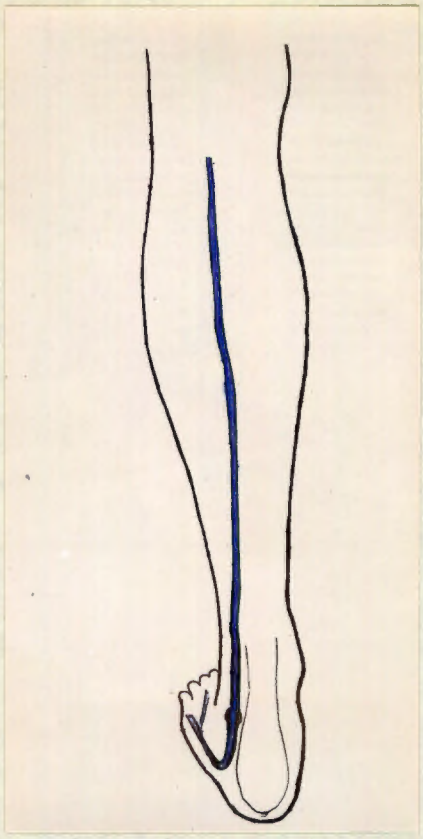


Fig. 93

Drawing of a leiomyoma of distal portion of small saphenous vein. (Case 10). Note the hypertrophy of vessel wall in its distal third.

Pain radiates up the leg and at times settles on the left side of the chest. Pain is not brought on by any definite act or by changes in temperature. It is very severe at nights and she has to resort to narcotics which give her slight relief. She has noticed that she sweats more in the right foot.

She has felt a small nodule on lateral side of tendo-achilles which is very tender to touch.

Two months previously, she was attended at Groote Schuur Hospital. A small nodule, size of a pea was palpated by medical officer.

Family History: Nine pregnancies. Two children died from unknown causes.

Previous History: Nil of note.

On Examination: Healthy coloured female, 40 weeks pregnant. Cardio-vascular system normal.

Locally, there is no evidence of dilated veins nor increased sweating of the right foot. There is no visible swelling nor discolouration of skin.

On palpation, a markedly tender area size of three-penny piece can be mapped out on lateral side of tendo-achilles 1½ inches proximal to its insertion (Fig. 93). On pressure over this area she experiences the pain described above. The lump previously mentioned could not be palpated, but some thickening under lateral border of tendo-achilles was present.

Measurements of length of legs and feet did not reveal any difference on the two sides.

X-Rays of right foot, did not reveal any bony abnormality.

In view of her long history of pain which was of severe intensity, I decided to explore the lower part of leg.

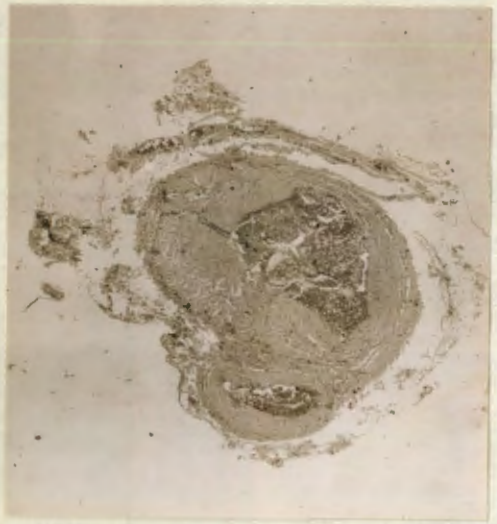
Operation - 8. 8. 47:

Operation under local anaesthesia, a vertical incision 2½ inches long was made ½ inch, lateral to tendo-achilles. The tender area was carefully mapped out and localized with a needle.

On reflecting the edges of the wound, a bluish area size of six-pence was seen in distal part of wound. On trying to dissect this out, there was free bleeding, suggesting a plexus of veins.

By careful dissection in subcutaneous tissue, a nodule oval in shape and measuring 3 x 7 mm. was observed. It had a bluish colour and was of firm consistency. Pressure on this tumour produced the characteristic pain.

At each pole of the tumour, a thick strand of tissue was attached resembling a nerve. On careful dissection, it was found to be a blood-vessel corresponding with the anatomical position of the small saphenous vein. The vessel was ligatured both proximal and



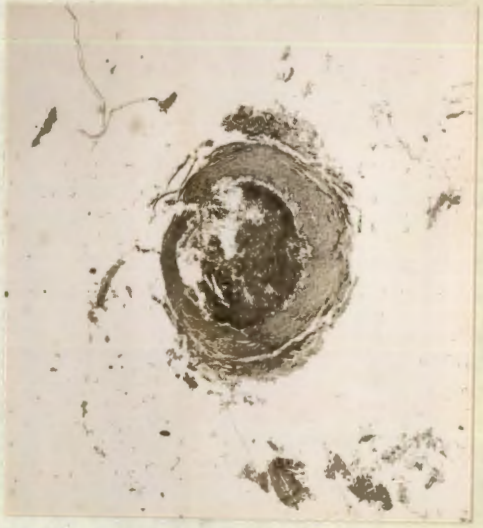


Fig. 94. H & E X 12

Fig. 95 Mallory X 12

Fig. 96 H & E X 12

Fig. 94. Represents the proximal portion of the vein. Note the hypertrophy of its wall resembling an artery. The lumen contains blood clot which is broken up by numerous valves. Note a smaller vein below.

Fig. 95. Represents a section through centre of tumour showing an encapsulated growth involving 2/3rds of circumference of vessel wall. Note the numerous vessels in the capsule. Mallory stain confirmed presence of muscle cells.

Fig. 96. This is a portion of vein distal to tumour showing less marked hypertrophy of its wall.

distal to the tumour and latter removed. The skin wound was carefully sutured after inserting a few deep catgut sutures.

Microscopic Study:

The sections are presented in three portions.

(a) The Proximal Vessel (Fig. 94)

This shows itself as a thickwalled vessel composed of muscle and fibrous tissue. The lumen of the vessel is very irregular, and several valves project from its endothelial lining. The vessel could readily be labelled an artery if it were not for the presence of these valves.

(b) The Tumour (Fig. 95 & 97).

The tumour is fairly well circumscribed by a connective tissue capsule. It appears to arise from approximately three-quarters of the circumference of the vessel.

The lumen of the vessel is rounded and contains numerous red blood corpuscles. There is a well-marked subintimal fibrous layer.

The bulk of the tumour consists of smooth muscle and fibrous tissue. This feature is nicely demonstrated by the van Gieson's stain. A larger vessel, coming

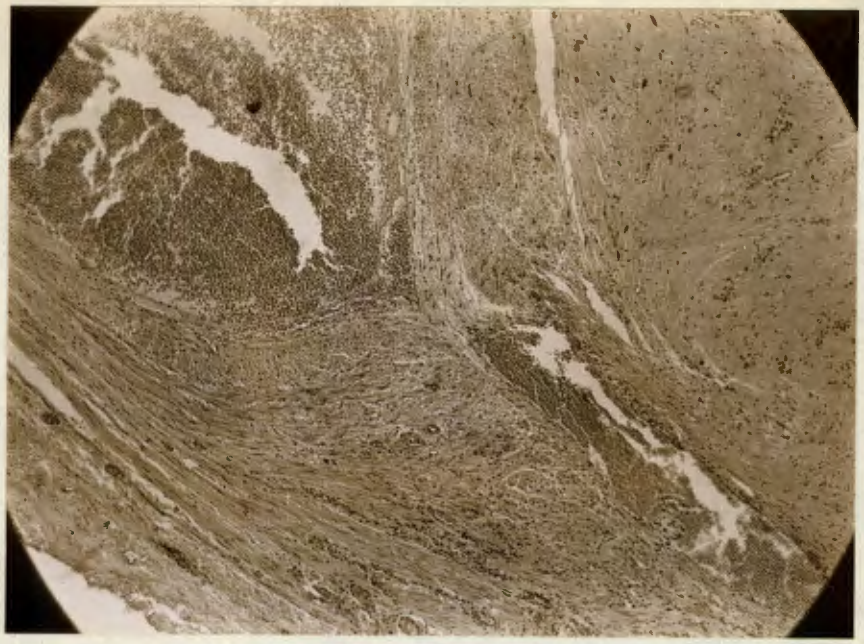


Fig. 97 H & E X 95

Picture shows muscle cells of tumour. The vessel lumen is visible on the left and narrow lumen of another vessel on the right.

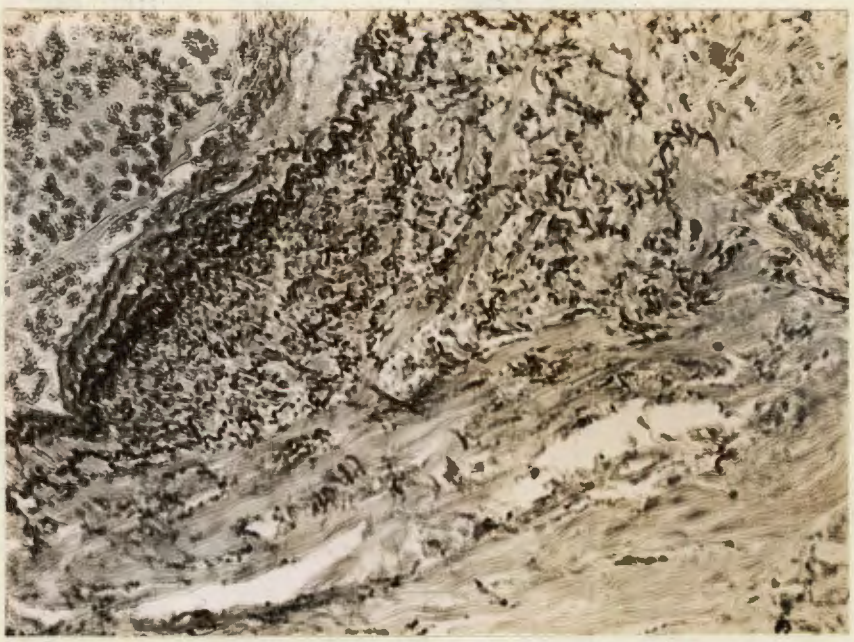


Fig. 98 HART'S X 440

Note the large amount of elastic tissue bordering the vessel lumen. The elastic tissue is scanty in the tumour on the right. Blood corpuscles in lumen is seen in upper left-hand corner.

off the lumen, enters the tumour and splits up into smaller branches.

(c) The Distal Vessel:

The distal portion of the vessel shows a thinner wall with a rounded lumen. Valves are absent in this portion of the vessel. (Fig. 96).

(Fig. 98) demonstrates the large amount of elastic tissue bordering the lumen of the vessel. In the tumour itself, the elastic tissue is scanty.

The structure of tumour is that of a leimyoma occurring the wall of a blood vessel.

Progress:

The pain subsided immediately after the operation and she has been free from symptoms a month later.

Comment:

This case offers an excellent example of a leiomyoma occurring in a vessel wall.

A very interesting clinical finding was the variation in size of the tumour. One investigator found a visible tumour on the leg about the size of a pea which he was unable to demonstrate on his second examination, a month later.

The tumour was located by finding the point of maximum tenderness on the leg. This fluctuation in size is due to contraction of plain muscle as was mentioned by Hagiwara (1933).

If her history was correct, the radiation of pain is a most unusual finding. (Stout 1937).

The time of onset of her symptoms suggests an overgrowth of plain muscle in tumour coinciding with the general hypertrophy of tissue which takes place during pregnancy. This is further confirmed by the absence of symptoms at termination of pregnant state. Sokolow (1873) noted that a myoma of nipple zone more than doubled size during pregnancy, each time decreasing in size following termination of pregnancy.

The close association of this tumour with a vessel and the absence of elastic tissue inside the tumour vessels, places it in the category of glomus tumours.

A further point of interest was the hypertrophy of the small saphenous vein and the thickness of its wall.

CASE 11.

De W. Aged 44 years Coloured Male

Occupation -------- Labourer

Complaint: He complains of a tender lump on right forearm - duration 5 years

HISTORY:

While on active service in Abyssinia in 1942 he noticed a small pimple on outer aspect of the right forearm. It was not associated with trauma. He did not experience any pain but felt only slight irritation of skin over it. It has gradually increased in size to that of a pea and for past 6 months has been painful. Pain is of a burning character over the lump but does not radiate. It is brought on by slight knocks and by contact with his coat sleeve. When pain is at its maximum he experiences a feeling of lameness in his arm. Pain is initiated by hot water but has no relation to cold. Excessive sweating of left limb was not noticed by patient.

EXAMINATION:

Perfectly healthy adult with no evidence of any cardio-vascular lesion.

Locally a small darkly pigmented nodule

Fig. 99

Leiomyoma of forearm (Case 11).

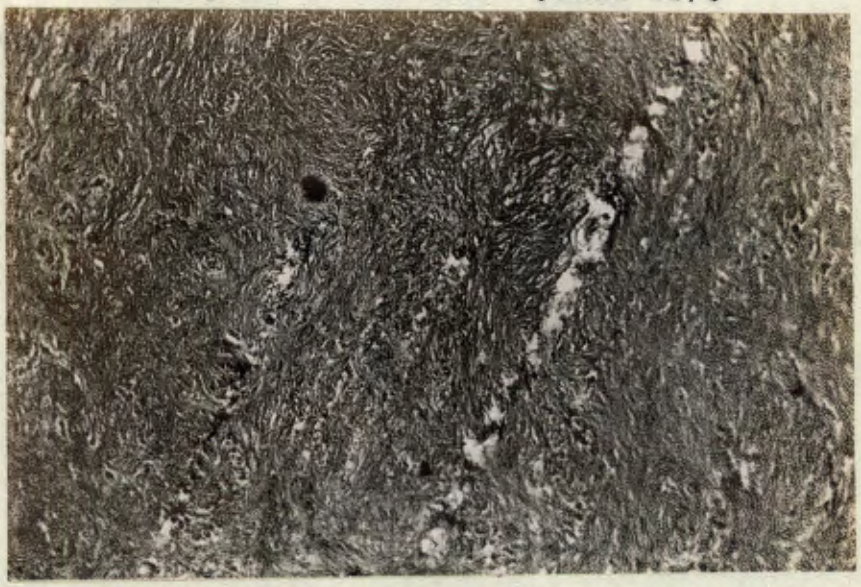


Fig. 100 Van Gieson X 60.

Diffential stain to show Muscle and connective tissue. The darker portion represents the muscle.

size of a pea, is situated on antero-lateral aspect of upper third of right forearm. (Fig. 99)

There is no evidence of dilated veins in the left limb.

Lump is of rubbery consistency, freely mobile in subcutaneous tissue but is attached to overlying skin. It is tender on palpation.

The right arm does not feel warmer than the left and there is absence of any sweating. The upper limbs are of equal length.

A Horner's syndrome was not detected.

Investigations:

Oxygen Estimation of samples of blood taken from median basilic veins by means of Van Slyke's apparatus revealed the following:-

At room temperature of 17°C.

Vol. percent oxygen right arm 5.5
Vol. percent oxygen left arm 6.1

There was no appreciable difference in oxygen levels of the two arms, although both readings were low. This can be explained by the low room temperature on day of examination.

Diagnosis: Leiomyoma of skin.

Operation: Under local anaesthesia a small localized tumour, size of pea was removed from forearm. There was no evidence of vascular attachments to the tumour.

Histology:

The histology is that of a cutaneous leiomyoma. This was clearly demonstrated by Van Gieson's stain, which shows up muscle in red and fibrous tissue in yellow. (Fig.100)

Comment:

The first impressions gained from this case were that we were dealing with a glomus tumour. The absence of severe hyperaesthesia and consistency of tumour were points against this diagnosis. We were further aided by the approximately equal oxygen estimations in the two limbs and the low reading obtained from affected limb.

C.

THE GLOMUS BODY IN VARIOUS PATHOLOGICAL CONDITIONS

Apart from glomus tumours, the glomus body may be involved in certain pathological conditions affecting the limbs. N.W.Popoff (1934) studied the Histology of the glomus bodies in the following conditions:-

1. Senile Arteriosclerotic Gangrene of the Foot (Fig.101)

In this condition no normal glomus units are observed and the number of glomus bodies may be reduced to 4 or 6 per square centimetre.

Here the pathological changes are due mainly to arteriosclerotic changes of the afferent arterioles. The endothelio-muscular elevations of the lumen of this vessel are absent. The elastic lamina becomes distorted and the intermuscular connective tissue increases in vessel wall.

These changes lead to marked functional changes of the glomus body as result of rigidity and patency of the afferent arterial wall. A larger amount of blood will be short-circuited through these fistulae and will lead to marked nutritional disturbances in the capillary bed.

Later, the preglomic vessels undergo hyalinization and interfere with blood-supply to the glomus body which undergoes atrophic changes.

Fig. 101

The glomus in arteriosclerotic gangrene of foot. (After Popoff 1934). Note distortion of elastic lamina and patency of lumen.

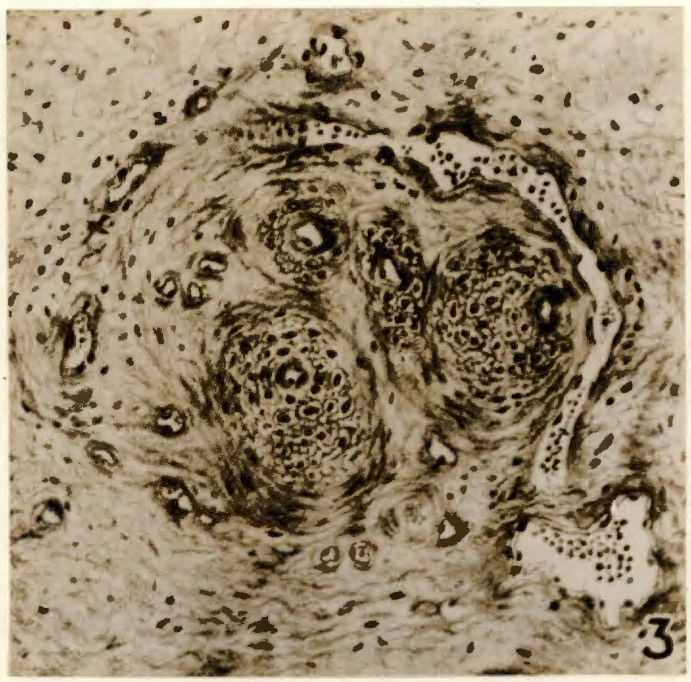


Fig. 102.

The glomus in diabetic gangrene of foot (After Popoff 1934) The fibrosis of glomus is evident.

In advanced cases, the afferemt portion of the anastomotic canal becomes sclerotic and the entire canal is transformed into a functionally uncontrollable channel. Through this fistula arterial blood pours continuously into the collecting veins. These veins now undergo similar changes as seen in congenital arteriovenous anastomoses. At first they become hypertrophic followed by dilatation of their walls. This will lead to venous stasis in the limb with all its sequelae.

2. Diabetic Gangrene of the Foot (Fig. 102)

Here the primary changes are first noticeable in the anastomotic canal where hyalinization of the sub-endothelial coat occurs. Later on fibrosis occurs in the glomus body leading to obliteration of the lumen of the canal. In many cases, not a single glomus body can be found.

3. Thrombo-angeitis Obliterans (Fig. 103).

In this condition the anastomotic canals are free from primary degenerative changes. The intimal and muscular layers remain unchanged. The glomus body may appear smaller as a result of fibrosis of surrounding tissues.

Popoff (1934) attributed the pathological picture to a vascular anomaly manifested by the presence

Fig. 103

The glomus body in Buerger's Disease (After Popoff 1934)

a,b and c.....veins
d and e.....arteries
f.....anomalous anastomotic channel.

of a different type of arterio-venous anastomosis

By doing serial sections on digits of cases with Buerger's disease, he found that some digital arterioles communicated with veins either by a terminal or lateral anastomoses. This anomalous anastomosis was present only in cases suffering from Buerger's disease and differed considerably from the normal glomus body.

The anomalous anastomosis possesses the following characteristics:-

(a) It arises from larger vessels in subcutaneous tissue.

(b) It is not coiled but single and straight.

(c) The lumen is larger than that of the anastomotic canal of the glomus body.

(d) The anastomosis has the structure of an ordinary artery and does not show the endothelio-muscular elevations.

(e) It is not under the control of sympathetic nervous system.

(f) The function of this structure is purposeless and detrimental.

(g) It will lead to a marked increase of oxygen in the blood. Thus in Buerger's disease, it can be shown that blood from an affected leg has a higher oxygen

content than blood taken from cubital vein of the same patient. (Goetz - not published yet).

4. Inflammation of digits

The glomus bodies are very sensitive to thermic, mechanical and chemical influences. The glomus cells disappear and the anastomotic canal is transformed into a large, distended capillary surrounded by inflammatory elements. In case of recovery, transformations of the affected structure into the proper glomus pattern takes place.

5. Supernumerary Fingers of Man

Cummins (1932) demonstrated that glomus bodies were absent from supernumerary fingers of man.

SUMMARY

1. The literature of the Glomus Body and Tumours has been reviewed.
2. By means of serial sections, the glomus bodies in the nail-bed were studied and reconstructed in wax.
3. Eight cases with glomus tumours, two with leiomyomata and one with congenital arterio-venous anastomoses of a limb were described.
4. A careful histological study of the glomus tumour was carried out.
5. The oxygen estimation of blood has (as far as is known) been done for the first time on a patient suffering from a glomus tumour.
6. The venous dilatation of limbs in patients suffering from glomus tumours has (as far as is known) been described for the first time.
7. A chapter was written on the physiology of arterio-venous anastomoses.
8. The venous congestion test and its relation to pain-production in glomus tumour cases was demonstrated.
9. Lastly, the histology of the glomus body in Buerger's disease, arteriosclerotic gangrene and diabetic gangrene was described.

ASPECTS RECOMMENDED FOR FURTHER STUDY

1. Physiological study of normal glomus body on the lines discussed in the chapter experimental physiology.

2. Reconstruction of a glomus tumour in wax.

3. Study of the coccygeal glomus.

4. The glomus bodies in pathological states with special reference to hypertension.

A C K N O W L E D G E M E N T S

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