Personal Paper

The teaching of anatomy and its influence on the art and practice of surgery

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At its quarterly meeting in October 1977 the Council of the Royal College of Surgeons of England approved the resolution passed by the Joint Conference of Surgical Colleges in Melbourne earlier the same year: "that undergraduate instruction in anatomy has, in the opinion of the English-speaking colleges, contracted to such a point at which it is no longer adequate as a basis for the practice of clinical medicine."[1]

My belief is that the teachers of would-be doctors have a duty to see that in their training students are compelled to use their reasoning powers. Anatomy is peculiar in that, if taught correctly, it can make the student think and correlate symptoms with systems. Not enough time is spent in making the student reason out the sequence of events that leads to a diagnosis of the symptoms presented by the patient. This reasoning process, I maintain, must begin with a consideration of anatomy, of the anatomical structures that relate to the symptoms, and of the anatomical organs that lie under the palpating hand, and a knowledge of how these structures are affected by normal function and by dysfunction.

Do not mistake me, I am not suggesting that the anatomist shall take over the role of the clinician; but it is our duty as anatomists to teach in such a way that the student becomes interested in the future of his work as a doctor, and that he does not forget the hatpegs on which he can place the fundamentals of physiology, pathology, and clinical symptoms.

What is taught and learnt when a person is young is the last to be forgotten. Anatomy is a fundamental subject basic to the training of the doctor, and what is taught early in the curriculum must be inculcated so that its principles are implanted in the brain and should at no time be forgotten. Learning depends on familiarity, teaching demands repetition. A message traversing the same neural pathway on several occasions finds its journey easier to accomplish the more often it is carried out, a property that the physiologists call "facilitation." Make some interesting observation or point, emphasise it, and repeat it at appropriate and opportune intervals, and the lesson is learnt never to be wholly forgotten.

Practical value of anatomy

It is a grave mistake on the part of those who plan medical training to curtail the time spent in the dissection room. The exercise of dissection teaches the qualities of care and attention to detail that are essential in a doctor's attributes. When I was a student lectures in applied anatomy were given in the anatomy department by clinicians in the final year of study. Now, if my information is correct, applied anatomy is not taught in all medical schools. Certainly students, when they come for their final period of surgical study, are remarkably deficient in the simplest anatomical knowledge.

Clearly the student must be taught basic structural anatomy in the anatomy department—that is, where the cadavers, specimens, slides, etc, are housed. For applied anatomy, instruction must of necessity be carried out where the material is to be found—namely, in the wards and the outpatient departments. This instruction should be given both by anatomists and by clinicians, possibly in partnership. These proposals may well provoke antagonism from the clinicians, but there surely will be few anatomists not eager to grasp the opportunity to demonstrate to the student the practical value of anatomy in a clinical setting.

It was fashionable a few years ago to carry out tenotomy of the tendo Achillis in the management of intermittent claudication of the calf muscles due to vascular insufficiency. This procedure caused the patient relatively little inconvenience when walking on the flat, but no one ever bothered to explain to the patient (or to the student) that synergistic control would be lost when he was descending the stairs and that he should hold firmly to the handrail. What is the value of relieving pain in the calf on walking while risking a fall down the stairs that might lead to a fractured skull?

I believe there are today few qualified doctors who have any real depth of anatomical knowledge, with the possible exception of the neurologists and the orthopaedic surgeons. For years Professor Telford in Manchester had been carrying out cervicodorsal ganglionectomy with access above the clavicle, with the patient's arm placed behind the back in the belief that the costoclavicular interval is increased in this position. He would not believe me when I pointed out to him that the costoclavicular interval is increased when the shoulder is depressed—that is, with the hand placed down by the side of the body. Similarly, during the early years of the war, a hospital surgeon and a lecturer from an anatomy department together wrote (when in the Forces) an article that was published in the *Lancet* showing how the weight of the soldier's pack produced "downward and backward retraction of the shoulder" that caused symptoms of pain in the arm, and this was alleged to be due to costoclavicular pressure on the brachial plexus. Downward and backward retraction of the shoulder is a contradiction in terms. When the shoulders are retracted they rise. When the shoulder descends the clavicle moves forwards. Here were three people who did not know or understand the movements and functional mechanics of the clavicle—the surgeon, the anatomist, and the editor of the *Lancet*. It is surprising how few anatomists and fewer clinicians know of the complex movements that the clavicle undergoes during manoeuvres of the shoulder region. A phlebogram taken with the arm by the side (fig 1) shows that the vein is unimpeded by the clavicle, which appears to be flattened. When the arm is raised to 180°

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the vein is seen to be slightly narrowed as it passes under the bone (fig 2). The clavicle now appears to have a convex curvature in an upward direction. Were it not for the anterior convexity of the medial half of the clavicle and the fact that it rotates in its long axis anteroposteriorly on raising the arm, the vein would be completely occluded each time the arm is raised.

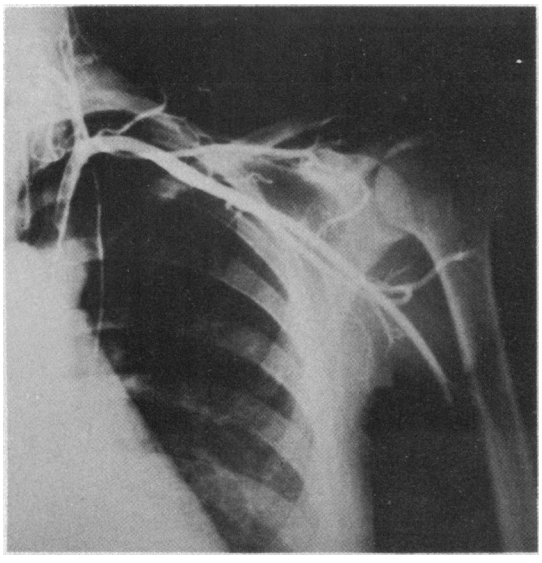

FIG 1—Phlebogram of axillary vein with arm by side.

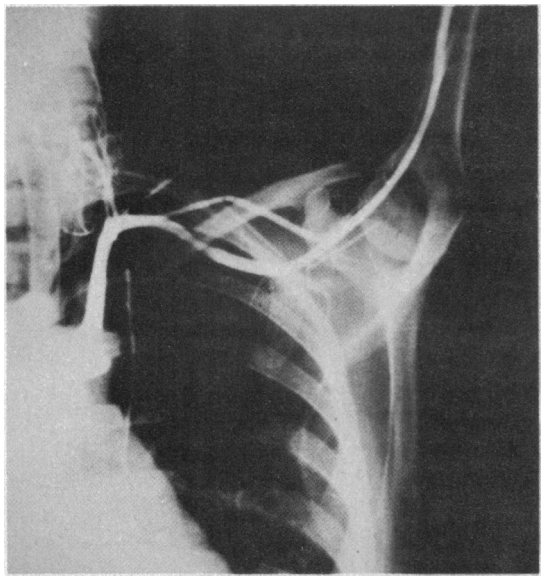

FIG 2—Phlebogram of axillary vein with arm raised to 180°.

Imagine the plight of the trapeze artists during their performances if the clavicle was a straight, uncurved bar of bone! How often do clinicians keep the patient's arm raised at 180° in management of swelling of the arm?

How many times do we see the surgeon in the anatomy department? I will give an example to illustrate the point. A 30-year-old woman, who had given birth to three children, consulted one of my junior colleagues with a history of pain down the outer side (deltoid region) of her right arm, duration three months. A radiograph of the thoracic inlet showed a cervical rib. Knowing my interest in cervical ribs he referred the patient to me. The situation to my mind was one for what I call "anatomical reasoning." This woman had possessed her cervical rib for 30 years and also during three pregnancies, but she had had symptoms only for three months. If the pain was caused by neurocostal incompatibility then it would have been distributed down the medial aspect of the limb, not over the deltoid region. What then had happened three months ago to bring about these symptoms? Direct inquiry elicited that she had suffered a severe attack of influenza. Here was the answer—the illness had produced muscular hyptonia especially of the right trapezius muscle, the right arm being dominant and used for carrying shopping bags, etc, which in turn had led to stretching of the upper trunk of the right brachial plexus with resulting pain in that particular area of supply. A course of shoulder exercises in the physiotherapy department cured the symptoms and saved her from mischievous surgical interference.

How often in the anatomy department do we miss the opportunity to teach those simple facts which have a bearing on everyday practice. I refer to the rich nerve supply of fascial sheets, muscle sheaths, periosteum, etc. When these structures are stretched as by intramuscular injections or pierced by needles, pain is caused. Every young doctor and nurse must be made aware of these things so that patients can be warned and an explanation given when injections are performed. At one time it was not uncommon to see sciatic nerve injury resulting from injections given into the buttocks. Fortunately, the nursing staff have now learnt of these dangers, but it is the duty of the anatomist to teach that the only safe place for an intramuscular injection is the lateral aspect of the thigh, and that these injections will be painful. Similarly, when muscles swell from any cause—for example, overexercise at the beginning of the athletic season leading to stiffness, or deep venous thrombosis causing tension under the fascial stocking of the calf—then pain is produced. Patients tolerate these symptoms more philosophically when an explanation of the cause is forthcoming. Why is the muscle sheath important to the surgeon? What is the weakest part of a muscle? Why does a footballer with a "pulled muscle" have to stop playing for long periods? Why does a ruptured tendo Achillis have to be repaired by operation to produce correct healing but a tenotomy of the tendon heals spontaneously in a few months? These are all questions that the anatomist can answer with ease. Similarly, no one ever explained to me why a patient with severe and gross varicosities of the leg veins never complains of pain but a patient with early varicose veins and mild varicosities suffers severe aching pain after prolonged standing. The explanation can be supplied easily by the anatomist who knows of the rich afferent nerve supply of veins that is stimulated during the development of early varices—but in full-blown varicosities the stimulus has ceased and the aching pain therefore disappears. Similarly, the practical implications of valves in the perforating leg veins should be emphasised in the anatomy department. Dodd and Cockett[2] have shown that the perforating veins rarely communicate with the main saphenous trunks. It is well known that the calf muscles, acting within their tough fascial stocking, not only force blood upwards but also suck it from the superficial veins into the deep channels, and that the efficiency of this system depends on the presence of valve cusps in the perforating veins at the level of the deep fascia. When these valves in the perforating veins become incompetent, blood is forced back into the superficial system and gravitational problems result.

Rewards of the pursuit of anatomy

I think that the pursuit of anatomy has its greatest rewards in general practice and surgery. So many clinical symptoms are due to disordered anatomy. Consider for a moment the vertebral column and its importance in producing symptoms when its anatomical configuration is disturbed. I cannot ever remember that I was taught the practical importance of the outlet foramina for the spinal nerves from the vertebral canal. The size of the foramina, the depth of the intravertebral disc spaces, the facet joints, all are important and when one or more is deranged

pain and disability result. Narrowing of disc spaces results in alteration of the shape of outlet foramina, interference with facet joints, and malalignment of vertebral bodies. These changes result in irritation of posterior nerve roots, especially on standing or walking but even after sitting in unsuitable positions. In the long term osteophytes develop to aggravate the condition.

Referred pain from osteoarthritic changes in the spinal column is perhaps the commonest symptom that takes a patient to a doctor. If this were pointed out to the anatomy student perhaps fewer patients would be referred to the vascular surgeon for what is commonly termed "intermittent claudication." Similarly, the anatomist can point out the importance of stimulation of an anterior nerve root in the production of pain. I am thinking of the *acute* prolapse of an intervertebral disc. The severe pain produced is due to intense muscular spasm often called cramp and is quite a different type of pain from that caused by irritation of a posterior nerve root. Irritation of posterior nerve roots causes many errors in diagnosis—for example, biliary colic has often been suspected when mid-dorsal arthritis was responsible for the pain. All of us can think of the gastrointestinal series of investigations carried out unnecessarily for symptoms referred to the upper or lower abdomen when the actual cause lay in the vertebral column.

Peroneus brevis

One of the most important muscles of the leg is, in my opinion, regarded with scant attention by the anatomists. I refer to peroneus brevis. Here is a muscle, dismissed in the textbooks in summary fashion in some 16 lines, yet its influence in establishing and maintaining the upright posture is of the first importance. As pointed out by Wood-Jones,[3] the attainment of orthograde bipedal progression is one of man's greatest specific distinctions. The inturned soles of the two feet face each other in infancy, but in early childhood there is a transition from crawling to attempts at walking upright.

The peroneus brevis muscle is perhaps the most important agent responsible for the eversion of the foot, below the level of the ankle joint that brings the whole sole of the foot, and not merely its fibular margin, into contact with the ground. Its function and importance are shown by the character of its distal attachment to the base of the fifth metatarsal bone. Here is an excellent example of structure depending on function. When a person for one reason or another loses the whole or part of his great toe, what is it that enables him to balance with the sole of the foot in contact with the ground? Most doctors would say peroneus longus, but it is peroneus brevis that takes the load. How often is a physiotherapist instructed in these particular matters? What is it that protects the ankle joint when walking over rough country that commonly results in "turning" of the ankle or, more accurately, acute inversion of the foot? It is the instant reflex reaction of peroneus brevis. So forceful is this muscular activity that at times it has been known to fracture the shaft of the fifth metatarsal bone just distal to its attachment. When this reflex reaction fails the distal attachment of the lateral ligament of the ankle joint is torn from its fixation to the calcaneum, and a "sprained" ankle results. The movements of inversion and eversion of the foot are usually described in anatomy books as being limited by ligaments. In fact they are controlled and limited by muscular action, and when these muscles are caught unawares then ligaments are torn from their bony attachments and painful swellings arise.

How often do anatomists teach the real reason for there being a collateral circulation round a joint? The clinician usually teaches that the collateral circulation is there to carry blood distally to a limb or to a part when the arterial supply is occluded by a pathological lesion. Nature did not develop collateral circulations for these reasons. She developed them especially in the neighbourhood of joints for two reasons, firstly, so that when the joint is flexed or moved into a position that temporarily occludes the main artery the limb beyond shall not become ischaemic. Have you ever thought about what the vascular supply of the thigh and calf muscles is like in people who squat for long hours at their work with hips and knees acutely flexed? We all know of the housemaid's prepatellar bursitis, but how many of us are interested in the blood supply

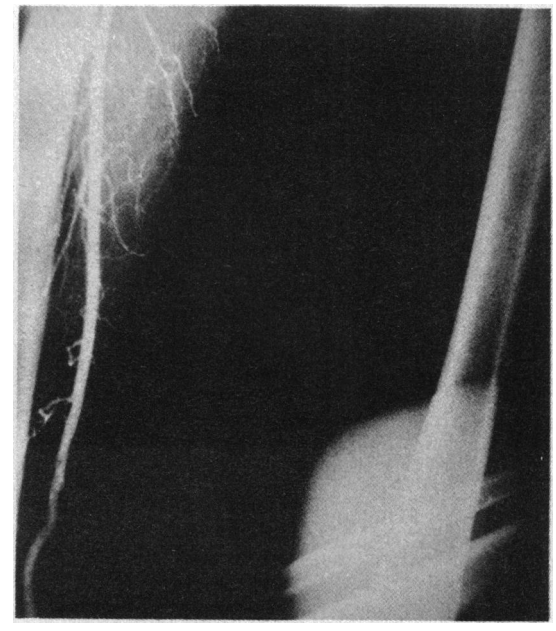

FIG 3—Vascularisation of thigh muscles with hip flexed.

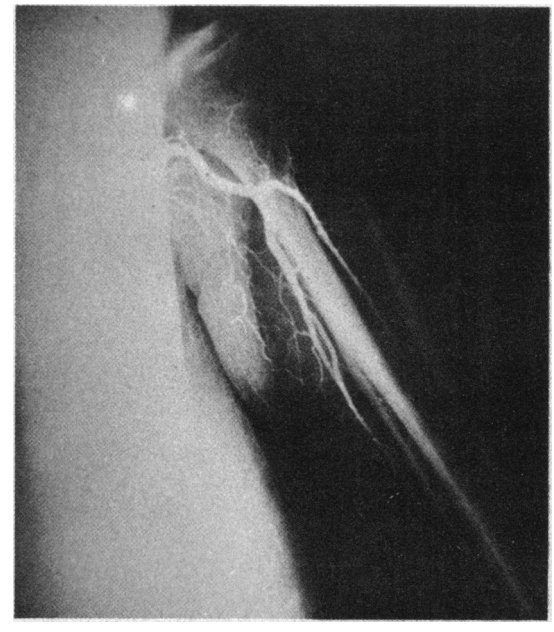

FIG 4—Vascularisation of calf muscles with knee flexed.

of her quadriceps or her calf muscles? During flexion at the hip and knee considerable changes occur in the vascularisation of the muscles of the thigh and calf over the next few minutes (figs 3 and 4). The second of nature's reasons for producing a collateral circulation around a joint is to keep it cool. The rich vascular network carries away the heat produced by repeated movement. How often do we teach these facts to students? How often is temporary vascular occlusion the cause of an indefinite aching in the limbs when examination provides no clinical answer to the problem?

Anatomy as seen by the surgeon

For the prospective surgeon the fundamentals of anatomy must be taught in the undergraduate stage. It is neither fair nor useful to expect postgraduate candidates to start from scratch to learn what should have been inculcated during preclinical years. Many preclinical students regard detailed anatomy as tedious, but for the performing surgeons apparently minor details have great practical importance—for example, the somewhat insignificant thoracoacromial artery enables the plastic surgeon to fashion a tube graft from the shoulder to the neck. In a similar manner he plans procedures in the groin based on what the student might regard as unimportant vessels. The recent development of replacement surgery and of microvascular reconstructive surgery depends entirely for its operative success on a total, detailed knowledge of topographical anatomy. For rehabilitation purposes a sound knowledge of functional anatomy is required. When certain important parts are missing from a limb it is necessary to intensify the activity of those muscles usually responsible for normal function. If anatomists taught the practical value of structures, seemingly insignificant to the student, interest would be stimulated in learning these details.

Technical surgery requires precise anatomical knowledge and is mandatory in whatever discipline one chooses to perform. In thyroid surgery every student knows about the danger that might accrue to the recurrent laryngeal nerve. The rare but occasional case where[4] the nerve passes transversely across the posterior aspect of the neck to reach the larynx, the so-called non-recurrent laryngeal nerve, is not so well known, but it has an anatomical explanation associated with the development of the aortic branchial arches. How often is this taught either in the anatomy rooms or at the operating table?[5] Only recently Van Vroonhoven and Muller[5] have reviewed 51 reoperations on the parathyroid glands, and they admit that the failure of the primary operations was due to inadequate anatomical knowledge and unusual location of the parathyroid glands, which led to imperfect surgical techniques.

Because doctors become interested in one particular subject and, in the fullness of time, acquire a specialist status they are not entitled to forget or ignore the generality of surgery, which demands a sound knowledge of the anatomy of parts that usually do not encroach on their specialty. It is a duty to remain conversant with ordinary anatomical structures so that should the occasion arise at any time they can acquit themselves with distinction, extricate themselves from difficulty, and bring the procedure to a safe conclusion. I have in mind a young colleague, a urologist, who had to remove a severely inflamed kidney on the left side. Subsequent to the nephrectomy one of my general surgical colleagues had to be called to deal with a necrosis of the descending colon. I had been faced with a similar problem some months previously. Removal of the kidney from within the fascia of Gerota ensured that the blood vessels to the colon remained intact.

Consider the question of inguinal hernia and the high recurrence rate after surgical repair. I believe the reason for this is that the surgeon does not understand the functional anatomy of the region. In the adult it is quite irrational to repair these hernias by the Bassini technique—joining the conjoint tendon to the inguinal ligament. The conjoint tendon forms a falx that is attached to the symphysis pubis and extends laterally on to the ileopectineal line (Cooper's ligament). Only if this anatomical configuration is reproduced during operative repair can a rational outcome be anticipated. Some surgeons talk of a high conjoint tendon. There is no such anatomical structure as a high conjoint tendon; like Hartmann's pouch at the neck of the gall bladder it is a pathological entity. What is not understood by either anatomists or surgeons is that the anatomical variations in the disposition of the conjoint tendon in many individuals is due to muscular forces acting on the blades of the iliac bones causing flaring, which in turn increases the suprapubic angle—the angle between the anterior superior iliac spines and the symphysis pubis. When this angle equals or exceeds 90° I have noticed that at operation for repair of an inguinal hernia the conjoint tendon is never in the form of a falx, as usually described in the anatomical text books. In these patients the conjoint tendon passes medially and joins the lateral border of the rectus sheath at various heights above the pubic tubercle. When the false pelvis is narrow the suprapubic angle is less than 90° and the conjoint tendon forms a true falx.

What happens is that in those individuals with a wide suprapubic angle as a result of strain from time to time the pubic attachment of the conjoint tendon comes adrift and slips up the lateral border of the sheath of the rectus abdominis muscle. This leads to what many American authors describe as a "high conjoint tendon."[6] Repair must restore the attachment of the conjoint tendon to the ileopectineal line.

Anatomy demonstrated on the cadaver

Anatomy, as seen by the surgeon at operation, is not quite the same as that demonstrated on the cadaver because the surgeon distorts the parts by traction and retraction, inflammation makes dissection difficult, and performance is often carried out in a restricted area. Therefore a thorough knowledge of anatomical structure is imperative—at operation a tube cannot be traced up the abdomen, as it can in a prosection, to see whether it joins the pelvis of the kidney and thus make sure that it is in the ureter. We must know what we are looking at and handling in situ. Some of the views set out above have been challenged by my co-examiners; never, I may say, by anatomists, always by surgeons.

Significantly, no patient has ever suffered from a doctor's knowledge of anatomy; many have benefited considerably because the doctor had good understanding of topographical anatomy.

Conclusions

I think I have given enough examples to illustrate how valuable is a sound knowledge of anatomy to the practising surgeon and also to the surgical pioneer. Professor Wood Jones[7] has said that the pursuit of anatomy should be the life-long study of those whose duty it is to interfere with the structure of the human body and mentions the heroic feats of the master surgeons such as Cheselden, Cooper, Bell, Syme, and others who continued to dissect the cadaver long after they became expert exponents of the surgical art. Unless the anatomist is allowed to continue to teach and instruct the medical student during the clinical part of his curriculum, and until the general practitioner and the practising surgeon[8] return with regularity to the dissecting room to demonstrate to the student the practical value of anatomical knowledge, then and only then will the heights of clinical diagnosis and surgical performance, to which we should all aspire, be attained.

References

1 *Ann R Coll Surg Engl* 1978;**60**:67.
2 Dodd H, Cockett FB. *The pathology and surgery of the lower limb*. Edinburgh: E and S Livingstone, 1956:53-62.
3 Wood-Jones F. *Buchanan's manual of anatomy*. 8th ed. London: Baillière, Tindall and Cox, 1949:45-8.
4 Wijetilaka SE. Non-recurrent laryngeal nerve. *Br J Surg* 1978;**65**:179.
5 Van Vroonhoven TJ, Muller H. Causes of failure in surgical treatment of primary hyperthyroidism: lessons from 51 successful reoperations. *Br J Surg* 1978;**65**:297.
6 Nyhus LM, Harkins HN. *Hernia*. London: Pitman Medical, 1964:28.
7 Wood-Jones F. *Life and living*. London: Kegan Paul, Trench Trubner and Co, 1939:92-3.
8 Jessop JH. Personal view. *Br Med J* 1979;ii:439.

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