on February 4th, 1931. Immediately after recovery from the anaesthetic the patient's own words were: "I feel more alive." He answered questions immediately, and his stammering, which had worried him before operation, had disappeared. His face had improved in appearance in that the mask-like expression had more or less disappeared. When he was able to walk, two days after operation, it was found that his right arm swung normally, and there was no limp or rigidity apparent; his reflexes had returned to normal. On March 10th he was eating well—he had not cared for food before operation. He had no hesitation about speech; he laughed spontaneously, and could carry on an intelligent conversation. He felt less depressed, and had daily periods when he felt quite well. He has not completely recovered, but he is very much improved.

Congenital Mental Deficiency

Congenital mental deficiency is usually gauged by physical accomplishment. For example, holding the head up, sitting up, walking, and talking, are usually considered expressions of intellectual development in children. If that is accepted and taken into consideration with signs of lack of mental development, the alteration of the circulation of the brain in a mentally defective infant patient, as shown in the following history, is important.

The patient, aged 2 years and 4 months, was unable to sit up, hold her head up, or make any attempt to stand or walk. She took no notice of her surroundings, was inattentive, and did not talk. At the age of 2 years she had exhibited irregular jerky movements; these were followed by fits, mainly affecting the left side. In the fits she bit her tongue, breathed heavily, and lost consciousness. When seen on February 12th, 1931, the patient had had ten fits within a few weeks. She was chronically constipated; perspired freely; reflex activity was normal. She underwent operation on March 24th, when a right thoracic sympathetic trunk section was performed. She sat up three days after operation, and stood up after four weeks. Excessive perspiration ceased seven days after operation. For the first five weeks after operation the bowel motions were never solid, and the patient did not need aperients; now she has an occasional dose of aperient, but never more than once a week, and her bowel movements are normal. I have had similar results following an operation on the right side, and a like result following an operation on the left side.

Deafness

Deafness was relieved in a patient suffering from retinitis pigmentosa. He had been deaf since birth, but had been partly relieved after the removal of adenoids. The effect of sympathetic trunk section on the right side was a relief of deafness on the left side, and vice versa. After the first operation he could hear band music, and now he can hear human speech. A peculiarity of his hearing is that there are gaps in the scale; he can hear a few notes, then misses a few, hears higher notes, and so on.

Headache

In another patient suffering from retinitis pigmentosa headaches were relieved. Previous to operation they had been as frequent as three or four times a week; now they have become rarer, and occur about once in a fortnight. Vertigo disappeared in another patient after operation.

Epilepsy

In the treatment of epilepsy in adults thoracic sympathetic trunk section has not been successful. I have operated upon five patients suffering from epilepsy and imbecility of varying degrees, but in no instance was the operative treatment effective in diminishing the number of fits. On the other hand, in children treatment by thoracic sympathetic trunk section is sometimes successful. I have had three instances in which fits of true epileptiform type have completely disappeared. When fits are asso-

ciated with spastic hemiplegia relief is almost invariable, following thoracic trunk section.

The experimental work outlined in this paper was carried out at the University of Sydney, and the expenses of the research were defrayed by the funds provided by Mr. George H. Bosch.

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Croonian Lectures

ON

LIVER AND SPLEEN: THEIR CLINICAL AND PATHOLOGICAL ASSOCIATIONS

BY

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LECTURE II

In my first lecture I dealt with the intricate vascular arrangements of the liver. I shall now begin by discussing the circulation through the spleen.

VASCULAR CIRCULATION THROUGH THE SPLEEN

I have already dealt very fully with this matter in my Lettsomian Lectures, and can therefore be brief. I must, however, draw attention to the most important points. The splenic artery, remarkable for its large size in proportion to the bulk of the organ, subdivides until, finally, each branch bifurcates to form two slender arterioles, named "penicilli" by Ruysch (1696). These small arterioles, as was emphasized by Cohnheim (1867), are end-arteries, and do not anastomose. On these penicillar branches lie the peculiar structures known as ellipsoids, a full account of which I have already published elsewhere. An important practical point having, I believe, a definite bearing on the mechanism of production of some of the splenomegalies was shown by Tait and Cashin (1925)—namely, that the ellipsoids act as potential valves, preventing all flow of blood backwards from the venous to the arterial side of the spleen. Quite recently, Nisimaru and Steggerda (1932), working in Barcroft's laboratory in Cambridge, have thrown doubt on this valve-like action of the ellipsoids; but in their experiments pressures of 40 to 50 mm. Hg or more were reached before the perfusion fluid passed back from the venous to the arterial side. The splenic vein is even more remarkable than the artery for its large calibre. Tait and Cashin (1925) were much impressed by its great contractility when stimulated electrically, and suggested the possibility that contraction in disease might well be of importance for the development of some human splenomegalies.

My views on the essential mechanism of the circulation through the spleen have already been published. Following the important observations of Barcroft and some simple experiments of my own with Cashin, I have concluded that, on the evidence at present available, the best working hypothesis (agreeing with many observed facts) is to regard the circulation through the spleen as twofold. The mechanism is suggested in the accompanying diagram. The first or ordinary circulation going on continually is a direct one, the blood being pumped through the splenic artery into venous sinuses, and from thence passing directly into the veins. The second circulation is intermittent, brought about by contraction and enlargement of the whole spleen. It consists of an emptying of

the pulp spaces through the wide stigmata or holes in the walls of the veins, and a filling again through the lateral channels in the walls of the ellipsoids. It seems probable that, since minor alterations in the volume of the spleen are constantly taking place, a small amount of blood is regularly being drawn out from the pulp into the veins to join the direct flow through the spleen; but the admixture of blood from the venous sinuses and from the pulp can, on this view, never be great unless the whole spleen has undergone definite contraction. With this two-fold circulation in mind, it is evident that blood cells may remain stationary and out of the general circulation in the spleen pulp for a period which has been estimated by Barcroft as half an hour.

The ellipsoids of the spleen are certainly one of the most remarkable structures belonging to the vascular system, and there is nothing like them in any other organ. They are the only valve-like structures in the spleen, and it must be remembered that neither the splenic nor the portal vein possesses a single valve. It is thus easy to

DIAGRAMMATIC REPRESENTATION OF A SPLENIC LOBULE

→ → → Closed splenic circulation
 Open splenic circulation, through the pulp
 M.C., Malpighian corpuscle. E, Ellipsoid. V.S., Venous sinus. P, Splenic pulp. R, Reticulum. S, Stigmata in wall of vein. a, Red blood corpuscle. b, Leucocyte. c, Endothelial cell from wall of blood sinus. d, Lymphocyte. e, Multipolar cell of pulp.

imagine how, in conditions of increased portal blood pressure, the first obstruction, so far as the spleen is concerned, is at the ellipsoids. In my opinion this is the important factor involved in the aetiology of the so-called "siderotic nodules," which are such a remarkable feature in a variety of chronic splenic enlargements.

Normal Blood Flow through Spleen

The total flow of blood from the spleen has been estimated by Burton-Opitz in the dog as about 1 c.cm. per second, whereas the total portal inflow to the liver is about 4 to 5 c.cm. per second. This figure must be taken as representing the constant or continuous flow of blood through the spleen, and not the amount delivered into the splenic vein when the organ undergoes contraction.

Nervous Control of the Splenic Circulation

We have little information on the nervous control of individual parts of the circulatory system of the spleen; but, following the work of Barcroft and his colleagues in recent years, we have very full knowledge of the mechanism of general splenic contraction and relaxation. In his early experiments on the effects of emotion or exercise on splenic contraction, Barcroft's work naturally suggested that adrenaline is the chief agent concerned in bringing about active contraction of the spleen. Quite recently, Barcroft, Nisimaru, and Puri (1932) have approached the subject directly by investigating the effects on the spleen of splanchnic nerve stimulation. Similar experiments have been carried out in the past by Schiff (1867), Roy (1881), and Schäfer and Moore (1896); but, as Barcroft points out, these experiments were all carried out before the discovery of adrenaline in the suprarenal glands; moreover, no distinction was drawn between the greater splanchnic and lesser splanchnic nerves. It has now been shown that nerve fibres to the spleen and to the suprarenal bodies are carried chiefly in the greater splanchnic nerves. Stimulation of these nerves (either on the right or left side of the body) causes immediate splenic contraction, evidently in two ways—a direct nervous effect, and an indirect effect through the secretion of adrenaline. Stimulation of the greater splanchnic nerve after removal of the suprarenal bodies is immediate, but less in degree than when these glands are left *in situ*.

PHYSIOLOGICAL CONSIDERATIONS

SOME FUNCTIONS OF THE LIVER AND THE SPLEEN

Having considered the chief anatomical questions (including, however, as was essential for the reasons given, the physiological problems of the control of the hepatic and splenic circulations), it is now opportune to discuss how far our knowledge of the functions of the liver and spleen may assist us in interpreting their relations in disease.

So far as the liver is concerned we can as yet say very little. We know nothing of any association between the numerous metabolic functions of the liver in respect of the proteins, carbohydrates, and fats and any functions of the spleen. The two well-recognized relations of the two organs are their peculiar vascular connexions and the presence of reticulo-endothelial cells in each of them. It seems obvious that acute circulatory changes in the spleen can have little effect on the liver, although the chronic degenerative changes (endophlebitis) found in the splenic vein in some splenomegalies may extend to the portal vein and to the liver. On the other hand, all circulatory changes in the liver, whether acute, subacute, or chronic, can scarcely fail to influence the vascular arrangements of the spleen. Metabolic activities, both of the liver and of the spleen, may certainly be upset by the vascular disturbances, especially if these are long continued. The common changes affecting the reticulo-endothelial cells in liver and spleen, and the diseases thus brought about, are fully dealt with subsequently, and need not detain us now. The physiological problems in relation to the vascular connexions of the two organs are most suitably considered here.

The spleen may be taken first, as the simpler problem of the two. The chief function of the spleen, excluding that in which the reticulo-endothelial system is concerned, is its contractility. The recognition of the spleen as a contractile organ is not new, and was indeed suggested as long ago as 1722 by Stukely in his Goulstonian Lecture before this College. The chief modern work on the subject is by Roy (1881), Schäfer and Moore (1896), Binet (1926 onwards), and particularly by Barcroft and his colleagues in Cambridge (1923 onwards). I have already dealt with

some of the earlier parts of Barcroft's work in my Lettsomian Lectures; but the problem is still in active evolution, and new observations are still being published with great regularity.

Liver and Spleen as Blood Depots

Recent work has all tended to centre round the potentialities of the spleen and liver as "blood depots." Barcroft has stated that in the dog approximately one-fifth of the blood corpuscles of the body may be held in reserve in the spleen, the blood of which is much richer in corpuscles than is the ordinary circulating blood. He suggests that the spleen of a dog of about 18 kilos is capable of holding at least 300 c.cm. of blood. Abderhalden and Roske (quoted by Ludwig), on the other hand, estimated the blood content of the spleen of a dog of 10 kilos as about 40 c.cm. only.

The amount of blood in the depot of the spleen compares very poorly with the amount which can be held in the liver, but Barcroft has pointed out that there is a fundamental difference between the two organs in their "depot" function. In the spleen, there is experimental evidence that the blood may remain held up in the pulp and out of the ordinary circulation for at least half an hour. In the liver, on the contrary, Barcroft, Nisimaru, and Ray (1932), have proved that there is not any stagnant store of blood such as exists in the spleen, and to a lesser extent in cyanosed skin. They have calculated the time taken by red blood corpuscles to traverse the liver in the following way. Samples of blood were taken from the femoral artery and from a tear on the surface of the liver (to obtain capillary blood) before and after a quantity of carbon monoxide gas had been introduced into the circulation. No real lag in the percentage-saturation of the gas was found between the two samples taken, and the conclusion was reached that in the liver there are no side tracks from the general current in which blood can lie.

The large amount of blood which may be contained in the liver has been accurately estimated by Grab, Jannsen, and Rein. After the injection of suitable doses of adrenaline it was found that different species of animals react rather differently, but one reaction is common to all. During the period of increased general blood pressure following the injection the outflow from the liver is greater than the inflow. This means, of course, that blood has been pressed out of the liver; but, as the blood pressure falls, the liver refills. In forty-four experiments it was found that, after adrenaline injection, blood can be extruded from the liver amounting to 59 per cent. of the total weight of the organ, or, as Ludwig (1931) calculates, about 250 c.cm. in an 11 kilo dog. On an analogy with this, although it cannot be more than a very rough analogy, the liver of a man weighing 70 kilos should be able to express about one and a half litres of blood into the general circulation (Ludwig), which is far more than the spleen can possibly yield.

Pick (1931) has recently been interesting himself in the blood depot function of the liver as it affects the filling of the right side of the heart—normally, and in cardiac failure. He quotes the observations of Grab, Jannsen, and Rein, which show that the liver contributes at least one-half, and in some cases as much as three-quarters, of the blood which the inferior vena cava brings to the heart. Thus, sometimes more blood comes from the liver than from the kidneys and lower limbs. Pick states that in cardiac failure the amount of blood in the liver may be as much as 68 per cent. of the total weight of the organ; since this blood must be actually within the circulation and does not stagnate (Barcroft), the actual amount of blood flowing slowly through the liver must, at times, be enormous.

THE POSSIBLE FUNCTIONAL INDEPENDENCE OF THE LOBES OF THE LIVER

This is a question which has been considered intermittently for a number of years. If certain suggestions could be proved to be true, it would assume very definite importance in relating one-half of the liver very closely to the spleen. Two quite separate problems are really involved: the anatomical and the physiological division of the liver into two parts. It is easier to consider both together, although different workers have generally, according to their individual bent, taken the matter up from one side only.

For clearness, it is necessary first of all to see how the commonly accepted anatomical division of the liver into its lobes has developed. G. Rolleston (1861), in a paper on the homologues of the lobes of the liver in mammalia, divided it into three parts—the right, left, and suspensory lobes—taking the suspensory or falciform ligament as his dividing line. Later, Flower (1872), following extensive investigations in comparative anatomy, divided the liver into two lobes, using as his division the falciform ligament, which contains on its free margin the ligamentum teres, the remnant of the left umbilical vein. Nearly all subsequent anatomists have followed Flower's description. Charnock Bradley (1909), however, chiefly as the result of studies on the embryo pig, concluded that the division into two lobes separated by the falciform ligament was erroneous, and that the fissures were not true anatomical divisions. He claimed that, embryologically, the liver develops as three masses, or lobes—one central and two lateral.

Anatomical Division of the Liver

The first real work suggesting, at one and the same time, that the accepted anatomical division of the liver was incorrect, and that there might be some independence between what he regarded as the true right and left lobes of the liver, was done by Cantlie (1898). The history of Cantlie's observations is well worth recording. He noticed, at the necropsy on an apparently physically healthy Chinese man who had committed suicide, that the right side of the liver was reduced to a small mass of fibrous tissue, whereas the left side was so hypertrophied as to leave the total weight of the liver little below normal. Cantlie made the important observation that the line of separation between the fibrotic part and the hypertrophied part lay along a line drawn from the fundus of the gall-bladder to the inferior vena cava. It occurred to Cantlie that this suggested the true dividing line of the liver into right and left lobes, rather than the line of the falciform ligament accepted by Flower and subsequent anatomists. Cantlie therefore proceeded to search for support of his hypothesis. He first noted that, if he cut across a normal human liver along a line drawn from the fundus of the gall-bladder to the groove made by the inferior vena cava on the posterior surface of the liver, the two segments were almost equal in weight. This point has been confirmed many times since then: the difference is rarely as much as 100 grams. He also observed that the branches of the hepatic artery, portal vein, and bile duct supplying the two segments are identical in size. He next applied some simple experimental methods, injecting two differently coloured fluids into the main right and left divisions of the portal vein. To his great interest the two colours met in a wavy line at his suggested line of partition. In an attempt to complete as far as possible the proof of his views, Cantlie quoted three clinical cases which seemed to support his hypothesis. He also stated that in severe injury by violence the liver tends to rupture along the dividing line described by him, and not at the falciform ligament.

Subsequent work, of different types and by many observers, is entirely in favour of Cantlie's view that the true anatomical division of the liver is along the line which he indicates, and not at the falciform ligament. But textbooks of anatomy, up to the present at least, retain the old and, as I believe, erroneous division made by Flower.

Evidence for Physiological Division

The evidence in favour of physiological or functional independence of the two lobes of the liver must now be considered, and will be found to be much less capable of definite proof. It must be remembered, however, that a considerable part of this work has been done in the belief that the division of the liver into two lobes at the falciform ligament is correct. Glénard (1890), to whom Cantlie's observations were obviously unknown, claimed that definite alterations in size, firmness, and tenderness, could be recognized in different parts of the lower border of the liver in certain diseases. He found, for instance, enlargement of the right hepatic lobe in diabetes mellitus, enlargement of the left lobe in alcoholic gastritis, and enlargement of the central part of the lower border in biliary diseases. From these observations Glénard was the first to suggest that different parts of the liver drain blood from different parts of the gastro-intestinal tract, and that there is therefore some physiological, and consequently pathological, independence of different parts of the liver. Glénard's suggestion was taken up at once by Sérégé, who was also unaware of Cantlie's work. Sérégé carried out experiments of two types: injections of methylene blue into various vessels entering the liver, and observations on the fate of small amounts of indian ink injected into the splenic and mesenteric veins. He was the first to make the very important claim that two more or less separate blood currents flow in the portal vein side by side—one from the mesenteric area to the right lobe of the liver, and one from the splenic area to the left lobe. This suggestion of what has been called "stream-lines" in the portal blood has recently attracted renewed attention, and is discussed in greater detail later on. Soon afterwards Sérégé also provided the first physiological evidence in support of the independence of the two hepatic lobes. His experiments consisted in estimating in dogs the urea content of the two hepatic lobes during the course of digestion.

Four Hypotheses Summarized

The work so far described details in chronological order the development of four hypotheses concerning the lobes of the liver:

1. That the true anatomical division of the liver is into two lobes, the division being along a line drawn from the fundus of the gall-bladder to the groove made by the inferior vena cava. (Cantlie 1898).
2. That the two lobes of the liver show definite physiological independence. (Sérégé, 1902).
3. That different parts of the liver drain blood from different parts of the gastro-intestinal tract. (Glénard, 1890.)
4. That two currents of blood flow side by side in the portal vein—one from the mesenteric area to the right hepatic lobe, and one from the splenic area to the left lobe. That is to say, that there is "stream-lining" of the portal blood. (Sérégé, 1901.)

Evidence for Anatomical Division of the Liver

The subsequent evidence for and against these four hypotheses may now be detailed. First, the question of the true anatomical division of the liver at the line suggested by Cantlie. There is practically uniform support for the general correctness of Cantlie's view, and among

the important papers are those of Gilbert and Villaret (1906), Wertheimer and Le Page (1896), Looten (1908), Bartlett, Corper, and Long (1914), and McIndoe and Counsellor (1927). The chief divergence of opinion is as to how far Cantlie's anatomical division is absolute. Wertheimer and Le Page, using sodium sulphindigotate injections, claimed that the bile ducts of the two lobes are absolutely independent and separate, but that the vascular system is not so independent; the same view is held by Looten. McIndoe and Counsellor, from their careful celloidin injection experiments, followed by dissolving away of the liver tissues to leave a celloidin skeleton, found that the independence of the two lobes is complete in respect of the bile ducts, but not definitely clean-cut in respect of the hepatic artery and portal vein, although no great cross-anastomosis exists. Certain points more recently made out concerning the embryological development of the liver have a definite bearing on the anatomical side of this problem. Some argument still remains; but it is now almost universally recognized by embryologists that the true plane of division of the liver lies between the two omphalo-mesenteric veins. The real division is thus not marked by any definite segmentation, and it is necessary to explain the fissures of the liver on some other plan. Actually, the adult human liver has very few deep fissures or lobulations when compared with that of the higher animals, but the suggestion that this proceeds from man's erect posture is not proven. It is now generally agreed that the human liver undergoes very great changes in shape from early foetal life right up to adult life, depending on changes in external pressure. Atrophy of some parts and hypertrophy of others ensue, and even in the normal healthy liver, as Toldt and Zuckerkandl (1876) pointed out long ago, small areas of bile ducts, arteries, and veins may be found "stranded" in fibrous tissue near the surface of the liver. So it is not to be wondered at that occasionally very abnormally shaped livers, or lobes of the liver, are met with in otherwise healthy individuals. A very complete account of these abnormalities has been given by Cullen (1925).

If this anatomical division be true, then some of the gross facts of morbid anatomy observed at necropsies or at operations should lend support to it. It is, of course, particularly lesions close up to the hilum of the liver, primary growths, and infective conditions within the liver itself, which should yield important information, since these lesions avoid all errors which could be due to the failure of "stream-lining" in the portal vein, if indeed this phenomenon exists. It is, however, frankly not easy to collect absolutely reliable information from clinical or pathological literature, the fact being that few, if any, clinicians or pathologists have recorded their cases of liver disease except in respect of the ordinary textbook division at the falciform ligament. A number of quite interesting cases are, however, on record; the great frequency of tropical abscess in the right lobe of the liver, not extending over to the left, may simply be mentioned. The three observations recorded by Cantlie are quite apt, and McIndoe and Counsellor also quote three very important necropsy histories in which either the right or left main branch of the portal vein, hepatic artery, or bile duct were blocked by disease. Herringham (1905), in an account of various deformities of the liver noted in nearly 3,000 necropsies at St. Bartholomew's Hospital, found eleven cases in which one lobe of the liver was completely undeveloped. He gives details of ten of these. In nine the left lobe was undeveloped, in one only the right. As a result of the maldevelopment the existing lobe was generally much hypertrophied, and might even have formed a palpable hepatic tumour. It must be pointed out that in diseases which spread by the

lymphatics, such as carcinoma, there is certainly no particular predilection for one or other lobe of the liver, since lymphatics pass from all parts of the liver to the glands in the portal fissure.

The information bearing on the possible physiological independence of the liver which has accumulated since the experiments of Sérégé, already referred to, is neither abundant nor very convincing. Loeb (1907), during experiments on the pharmacology of iodine compounds, noted that in several experiments the left side of the liver contained less iodine than the right. Gideon Wells and Hedenburg (1912), while carrying out experimental injections of iodine compounds for a purpose related to the possible treatment of tuberculosis, say "the statement of Loeb that the left lobe of the liver regularly contains less iodine than the right we can corroborate in part only." Actually, in nineteen experiments ten showed an increase in the right lobe compared with the left, and two experiments exactly the opposite result.

"Stream-lines" in the Portal Vein

The hypothesis, first suggested by Glénard, that different parts of the liver draw blood from different parts of the intestinal tract, and the corollary that two, or even more, streams of blood run side by side without much admixture in the portal vein, received severe criticism, as well as some support, in the early days following its publication. One of the chief critics was Bauer (1909), who published an able paper entitled: *L'Indépendance des lobes du foie est hypothèse*. From his experiments Bauer insisted that in the living animal there is not any double current of blood—mesenteric and splenic—in the portal vein, but that the whole mixed portal blood enters the liver. He admits that his belief in the absence of a double current in the portal vein does not invalidate in the least the hypothesis of a complete anatomical separation of the liver into the halves suggested by Cantlie. His final conclusion on the general question of the independence of the two halves of the liver is: "*une indépendance relative, oui—mais sur ce point tout le monde est en accord. Une indépendance absolue? Certes non.*"

In recent times the question of "stream-lining" in the portal vein has been very fully investigated by Bartlett, Corper and Long (1914), Copher and Dick (1928), and Dick (1928). It is in the first of these papers that the term "stream-lines" is used, and it is pointed out that the existence of these is well known to all hydraulic engineers. Two practical examples are given: (1) A muddy tributary joining a river—the river may remain half-muddy and half-clear for long distances. (2) Contamination of one side of a river with pathogenic micro-organisms from sewage—towns on one bank suffer from epidemics, while those on the other bank escape. Bartlett, Corper, and Long, who point out that the portal circulation and distribution of portal blood to the liver in the dog differs considerably from the human arrangement, carried out two series of experiments in dogs. In one series fat globules were injected into radicles of the portal vein to produce hepatic emboli; they were easily recognized histologically by the ordinary methods of staining fat. In the second series copper salts were introduced into the lumen of various isolated segments of the intestine, the amount of copper being subsequently estimated in the two lobes of the liver. From all their experiments these authors concluded that physiological independence of the two halves of the liver exists; but it is not sharp, and overlaps. They believed that the question of mixing of streams in the portal vein depends on a number of factors, such as angle of inflow, viscosity of fluids, and distance of flow in the common trunk.

Copher and Dick (1928), and Dick (1928), the most recent experimenters in this field, used living animals and also a new technique. Trypan blue dissolved in blood serum was employed as the injection fluid, since this dye has especial advantages in that it is light in weight, and also is permanently fixed in the tissues as a blue colour by formaldehyde. The actual flow of the dye in the portal vein was watched in living animals by arranging a powerful light behind the portal vein. According to these authors three main stream-lines in the portal vein could be definitely made out, maintained by the splenic, large mesenteric, and small mesenteric veins, which in the dog are the three largest vessels contributing to the portal blood stream. Dick notes that the individuality of these three currents was remarkably maintained, and he is a firm believer in the stream-line hypothesis.

RELATIONS OF THE THREE INTRAHEPATIC VASCULAR STREAMS TO THE NUTRITION OF THE LIVER CELLS

This is quite definitely a matter of consequence for the interpretation of the diseases which we are to consider. The clinical aspects of occlusion of one or other of these vessels has been reviewed by Winternitz (1911), in whose paper the important literature may be found. Partial or complete obliteration of the portal vein is by no means uncommon in cases diagnosed clinically as splenic anaemia. In my lectures on diseases of the spleen (1931) I placed these cases in a separate group under the heading "Thrombophlebitic splenomegaly," and referred to the important papers of Dock and Warthin (1904), Dévé (1908), and Warthin (1910) on this part of our subject. Obstruction of the hepatic artery is uncommon, and generally due to aneurysm of that vessel. A complete blocking of the hepatic veins in man is excessively rare.

Portal Vein

The effect of ligation of large branches of the portal vein in animals has been very fully investigated by Rous and Larimore (1920). Between the twelfth and fortieth days after this experiment has been carried out in rabbits the parenchyma of the part of the liver from which the portal blood has been cut off is found to have undergone atrophy. The tissue indeed practically disappears, leaving a skeleton made up of the blood vessels and the bile ducts; it is noteworthy that no fibrosis ensues. Rous and Larimore confirmed the previous observations of Steenhuis (1911) that the Kupffer cells in the atrophic zone become pigmented, are often distended to a spherical or egg shape, and are definitely increased in number. As atrophy proceeds in the part of the liver supplied by the ligatured vessel, the remainder of the liver undergoes tremendous hypertrophy, and, finally, may surpass in size the whole original liver. The curious fact was also made out that the atrophy of the one area is entirely conditional to the hypertrophy of the other. If hypertrophy be prevented in the part of the liver still supplied with portal blood by tying the bile ducts, the atrophy in the other part ceases to progress. The rough general implication of these experiments would seem to be as follows. The portal vein supplies the hepatic glandular cells with the metabolic products on which they work, and the cutting off of this supply causes gradual atrophy of the cells from disuse, since their normal functions are no longer exercised. On the other hand, the arrest of this atrophy, which ensues when hypertrophy of the portion of liver with an intact portal blood supply is prevented (by bile duct ligation), can be explained in the following way. The metabolic substances, carried to the liver and finding no large enough hypertrophic area to deal with them, pass on into the general circulation and return to the entire liver by the intact hepatic artery. Thus the whole liver receives its material for work, and atrophy ceases to progress.

These experimental principles are of decided importance for the elucidation of some of the problems of hepatic cirrhosis in man, but the experiments themselves also afford an excellent lesson in the difficulty of directly applying results obtained in animals to human disease. A large number of cases of thrombosis of the portal vein are on record, in which, at necropsy, the liver appeared to be normal in every respect. In some of these the old thrombus had been canalized and the portal circulation to some extent restored. In others, in which this phenomenon had not occurred, the hepatic artery had apparently been able to take over the complete blood supply of the liver cells. If any atrophy of the human liver occurs following portal thrombosis, as after the ligation experiments in animals, the atrophic area must soon disappear without leaving a trace.

Hepatic Artery

The effects of experimental ligation of the hepatic artery or its main branches in animals are entirely different from those obtained with the portal vein, immediate necrosis of hepatic cells being the result, and not gradual atrophy. Cameron and Mayes (1930), who give a full historical account of the effects of occlusion of the hepatic artery in man and in animals, point out (as was perhaps not sufficiently realized by Rous and Larimore) that results depend to a considerable extent on the anatomical arrangement of the vessels, which may vary greatly in different animal species and even in man. Rapid occlusion of the hepatic artery in man may be associated with swift and fatal necrosis of the liver, whereas with the slower obstruction due to aneurysm no changes may ensue after ligation of the artery.

Hepatic Veins

The effects of obstruction of the efferent vessels of the liver have been studied by Bolton (1914), and by Bolton and Barnard (1931). Sudden total occlusion of the inferior vena cava between the liver and the heart as a rule causes death of the animal within a few hours at most. By an ingenious experimental method Bolton has been able to obstruct partially the inferior vena cava with a constricting band between the liver and the heart, thus inducing great venous congestion of the liver, ascites, and other signs of increased portal pressure. In his first paper Bolton describes the course of events in a monkey, which, after being subjected to a partial obstruction of the inferior vena cava, survived in good health for a year. When the animal was then examined a complete obliteration of the lumen of the inferior vena cava was found, resulting in widespread degeneration of the liver parenchyma, especially towards the centre of the lobules. In these degenerated areas fibrosis was absent. In Bolton's second paper (with Barnard), cats were used and killed at intervals of 4 to 113 days after partial obstruction of the inferior vena cava in the same situation. It was found in these experiments of widely differing duration that the essential lesion consisted of necrosis of the liver cells in the central part of the lobules, leaving islets of intact cells around the portal canals. The necrotic cells soon disappear, their place being taken by dilated sinusoids; no trace of fibrosis is ever observed. The absence of fibrosis in all of these experiments which involve obstruction to one or other part of the blood supply to the liver is a point of very great importance.

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RECENT ADVANCES IN THE TREATMENT OF FRACTURES*

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(With Special Plate)

It is well recognized that in the treatment of fractures faulty alignment, over-riding, and all forms of malunion give rise to serious disability. But other equally serious and equally common causes of disability have not received the recognition they deserve. Too commonly the surgeon's attention has been focused on the bones, to the exclusion of other parts of the limb. In the determination to avoid malunion, joints have been unnecessarily immobilized, and irrecoverable stiffness has been allowed to develop. Colles's fractures may still be seen, perfectly reduced and united in excellent position, but associated with serious and frequently permanent stiffness of the metacarpo-phalangeal joints. Very frequently these disabilities, which are not due to the primary injury, but appear during treatment and in consequence of it, are even more serious than the disability which the treatment sets out to cure.

MAIN OBJECTS OF TREATMENT

It is of course essential, not only that a fracture shall be perfectly reduced, but that the fragments shall be completely immobilized for a period of sufficient duration

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