

POST-OPERATIVE THROMBOSIS AND EMBOLISM.*

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THROMBOSIS and embolism comprise so large a part of post-operative affections of the heart and blood-vessels that my paper shall be confined to them, including sepsis so far as it stands in intimate relation to these complications. This intimate relation is well known and not denied, for although infection is probably not the cause of the majority of the cases of post-operative thrombosis, it plays an important rôle in its causation, and thrombosis and embolism enter largely into the processes by which an infection is conveyed from one part of the body to another.

A thrombus has been defined as a solid mass or plug formed in the living heart or blood-vessel from the constituents of the blood. A thrombus formed from the circulating blood is at first parietal or mural, but by continued growth it may fill the vessel and thus become an occluding or obstructive thrombus. A primitive thrombus, caused by local conditions, may be the starting point of a continued thrombus, extending in the course of the thrombosed vessel and perhaps into communicating vessels. A secondary thrombus is one which starts from an embolus of thrombotic material.

Thrombi are called cardiac, arterial, venous, or capillary, according as they occupy one of these portions of the circulatory system.

The general causes of primary thrombosis are given as follows: A slowing or other disturbance of the blood current, changes in the vessel or heart wall, and changes in the constituents of the blood. The following classification, having as a basis the causation of thrombosis, has also been made:

1. Inflammatory thrombi, which are produced through acute or chronic inflammation of the wall of the heart or blood-vessels. As a consequence of the inflammation, the wall is thickened and the endothelium injured.

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2. Traumatic thrombi produced through injuries to the vessel wall. To this classification belong those thrombi caused by ligation, severing, or tearing of the vessel.

3. Compression or dilatation thrombi, which are caused by a slowing or stagnation of the blood stream. The compression can arise by the pressure of tumors, exudates, etc., and the dilatation may be due to actual disease, loss of elasticity, or excessive thinning of the vessel wall. Certain cardiac thrombi probably come under this head.

4. Marantic thrombi, which are due to diseased conditions of the blood, degeneration or weakness of the heart, and slowing of the blood stream.

It is difficult to estimate which of the factors in producing thrombosis is of greatest importance in causing the post-operative variety. The recent interesting and important work of Carrel and Guthrie on the anastomosis of blood-vessels and the transplantation of viscera would seem to show that infection and injury to the vessel wall are of primary importance. They found in their work upon animals that where their technique was rigid and the endothelium of the vessels was accurately adapted, thrombosis occurred but rarely. However, infection would not seem to be the most important element in the post-operative variety, which occurs much more frequently (no matter where the seat of operation is) in the veins of the lower extremity, especially the left one.

All of the causes just mentioned may act after operation to cause thrombosis of these vessels. It is a fact that thrombi are more likely to form after operations for myoma or carcinoma of the uterus and large ovarian tumors. In these cases the blood formation is interfered with by loss of appetite and general ill health, the nutrient material of the blood is utilized in supplying nutrition to the tumor; and in many cases large quantities of blood are lost both before and during operation. From these causes there is frequently in these patients marked anemia, the number of white blood corpuscles, blood platelets, and the amount of fibrin are relatively increased and the blood is thus apparently rendered more liable to coagulate. Schwab, however, in a recent article (*Münch. Med. Wochensch.*, Vol. III, No. 51) could find no relation between the amount of hemoglobin and the time of blood coagulation.

The factors of most importance, then, would seem to be injuries

and diseased conditions of the vessel walls, and a stagnation or slowing of the blood current. In many of the cases where the thrombosis is most likely to occur, the vessel wall is dilated or otherwise diseased, due to pressure of the tumors prior to operation and to pathological changes in the blood. The blood current is slowed, due to weakened or diseased heart, the recumbent position, the small amount of fluid ingested, the loss of blood, and the distance from the heart. Finally the increased frequency with which thrombi occur in the left leg can be explained by the passage of the left iliac vein beneath the rectum or sigmoid flexure of the colon and the right iliac artery. Owing to its greater length and its course obliquely across the posterior wall of the pelvis, this vessel is subjected to greater pressure and trauma before operation in cases of these large tumors, and as a consequence there is a greater liability of its walls becoming diseased. After operation the same influences (less the tumor) act, and consequently there is more likelihood of stagnation of the blood current in the left than in the right iliac vein.

It is interesting and important to know what finally becomes of the thrombi. They may soften or break down, become organized, or undergo calcification. The softenings are divided into simple or bland, septic or purulent, and putrid.

The simple softening is thought to be due to the action of a ferment, and the septic and putrid to the action of pyogenic and putrefactive bacteria respectively. These softenings may lead to the dislodgment of pieces of the thrombi, which are then known as emboli, and these are transported by the circulation to various parts of the body. When calcification occurs, phleboliths or arterioliths are formed. The organization of thrombi, *i.e.* the substitution for the thrombus of vascularized connective tissue, takes place in the majority of cases. The tissue which replaces the thrombus is derived from the wall of the blood-vessel, new blood-vessels springing from the vasavasorum, and the endothelium and connective tissue being derived from like cells in the vessel wall. Lacunar spaces lined with endothelium may form throughout the thrombus, the latter becoming gradually disintegrated and absorbed. The newly formed tissue becomes fibrous and contracts, and there may result a fibrous plug, a cavernous structure with blood spaces, or a restoration of the lumen of the vessel, with perhaps a few bands crossing it.

Embolism is defined as the impaction in some part of the vascular system of any undissolved material brought there by the blood current. The transported material is called an embolus. Emboli are usually derived from thrombi. Fat, air, and tumor cells may form the embolus, but these are of little importance in the post-operative variety. A thrombus from the systemic veins or right heart causes pulmonary embolism, except in those cases of crossed embolism, where the embolus passes through an open foramen ovale or where the embolus is stopped in the heart. When a piece of a thrombus is detached from the left side of the heart, the pulmonary veins, or the systemic arteries, the embolus lodges in a systemic artery. Finally, an embolus from the portal system of veins lodges in the liver.

As before stated, there is an intimate relation between sepsis and thrombosis and embolism. Post-operative cardiac disease is usually due to the action of bacteria which enter the blood current and produce endocarditis, pericarditis, and, at times, cardiac thrombi. The bacteria of wound infection and the gonococcus, the bacteria most frequently encountered in gynecological operations, cause a considerable proportion of the cases of acute endocarditis. The acute endocarditis thus set up is the thrombus from which, in certain cases, emboli of the post-operative variety are derived which lodge in the lungs, kidneys, spleen, mesenteric arteries, the brain, or arteries of the extremities.

Having briefly considered the subject of post-operative thrombosis, embolism, and sepsis as related to the two former, I will take up the various varieties.

LOWER EXTREMITIES.

I will begin with the lower extremities, as thrombi occur much more frequently there after gynecological and abdominal operations.

Schenck (*N. Y. Med. Journal*, Sept. 6, 1902) states that after 7,130 gynecological operations at the Johns Hopkins Hospital there occurred 48 cases of thrombosis of the veins of the lower extremities. The operations included nearly all of the usual gynecological ones, but the affection occurred much more frequently after operations for the removal of fibroid tumors, ovarian cysts, and carcinoma of the cervix.

Albanus (*Beitr. Klin. Chir.*, XL) found that in 1,140 laparotomies in the new General Hospital at Hamburg-Eppendorf, there occurred 53 cases of recognized venous thrombosis, all but one

occurring either in the pelvic veins or the veins of the lower extremities.

The diseases for which the laparotomies were performed were as follows:

1. Carcinoma of the esophagus.....	1
2. Diseases of the stomach.....	8
(Carc., 6; ulcer, 1; and pyloric stenosis, 1.)	
3. Diseases of the appendix.....	10
4. Diseases of the large bowel (all carcinomas).....	3
5. Diseases of the liver with gall-bladder.....	7
(Liver abscess, 1; chronic icterus, 1; carc. of liver and gall-bladder, 1; diseases of the gall-bladder, 4.)	
6. Sub-diaphragmatic abscess.....	2
7. Ileus, 1; perforative peritonitis, 1; tuberc. peritonitis, 1; general carcinosis of perit., 1; sarcoma of the abdom. wall, 1; total.....	5
8. Diseases of the female genital tract.....	19
(Carc. of ovary, 3; carc. of uterus and ovaries, 1; carc. of uterus, 1; pyosalpinx, 5; ovarian cysts, 4; myoma uteri, 3; prolapsus uteri, 1; extrauterine pregnancy, 1.)	

Sonnenburg in a series of 1,000 operations for appendicitis observed 30 cases of thrombosis. These were distributed as follows:

Right leg	9
Left leg	6
Both legs	2
Portal vein	2
Inf. vena cava	1

Clark (*Univ. of Penna. Bull.*, July, 1902), in 3,000 laparotomies performed mainly for gynecological diseases, found 42 cases of femoral thrombosis. The diseases were as follows:

Myoma uteri	16
Cystoma ovarii	10
Retroflexio uteri (simple and adherent).....	5
Carcinoma uteri	5
Appendicitis	2
Salpingitis and peri-oophoritis	2
Floating kidney	1
Cancer of the pylorus.....	1

Except after operations for appendicitis, thrombosis of the femoral vein occurs oftener in the left leg. As before stated, the

frequency of thrombosis in the femoral veins and the greater number which occur in the left leg should, it would seem, offer some plausible explanation of the etiology of the condition. The only rational explanation of this relative frequency, then, would seem to be slowing and disturbance of the blood current, due to diseased heart, general weakness, pressure of the pelvic viscera (sigmoid, vessels, etc.), and to diseased endothelium of the veins prior to operation.

Thrombosis and embolism of the arteries of the lower extremities are of very infrequent occurrence following gynecological and abdominal operations.

The frequency with which thrombosis occurs in the ovarian vein is impossible to estimate, the symptoms being obscure, and unless an autopsy is done it generally escapes observation. My own impression, obtained from autopsies upon patients dying from post-operative pulmonary embolism, would make it of greater importance than is usually attributed to it. Lotheisen found in 66 cases of pulmonary embolism that the greater number (40) came from the veins of the lower extremity; and next in frequency were from the pelvic veins.

In the first 39 cases of femoral thrombosis which occurred in the gynecological wards of the Johns Hopkins Hospital the shortest time after operation when symptoms of the affection made their appearance was seven days, the longest twenty-eight days, the average time being sixteen days. I can find no satisfactory explanation why this delay in symptoms should occur, unless it is that it requires a considerable time for complete plugging of the vessel to be accomplished, the thrombus formation beginning as a parietal form and finally becoming an obliterating thrombus.

PORTAL VEIN.

Thrombosis and embolism of the portal vein and its branches probably occur much more frequently than is usually thought. After resection of the intestine, gastroenterostomy, operations for incarcerated hernia, appendicitis, volvulus, intussusception, and cholelithiasis, thrombosis of the mesenteric and portal veins undoubtedly not infrequently occurs. Unless a complete occlusion takes place, or the thrombotic or embolic process is of the septic variety, it may readily escape notice. The portal vein, although a terminal vessel, has so abundant a capillary anastomosis that as a rule embolism or thrombosis of its hepatic terminals causes no interference with the circulation of the liver. The variety

which has been most frequently observed is septic pylephlebitis. A number of such cases have been reported; Gerster, in 1,180 cases of appendicitis, saw nine cases of this affection. Quincke (Nothnagel's Encyclopedia) considers as the cause of liver abscess, first, dysentery; second, appendicitis; and third, cholelithiasis. Langfeld, in 112 cases of appendicitis, saw pylephlebitis four times, while Fitz, in 257 cases, saw pylephlebitis and liver abscess eleven times. Hart, Sonnenburg, Bärensprung, Kelly, and numerous other writers report cases of the kind. The observations of Gussenhauer are interesting. He believes that most of the lung affections following incarcerated hernia are embolic in origin. As the mesenteric veins empty into the portal vein, most of the emboli must first lodge in the liver, and from this organ secondary emboli pass to the lungs. A few may pass through the anastomosis between the portal vein and the inferior vena cava, while very small emboli may possibly pass through the liver directly to the lungs. Certain thrombotic processes extend to the portal vein through its anastomosis with the pelvic veins. Gerster's observations may give a possible explanation of the absence of symptoms in many cases of portal and mesenteric thrombosis. He says, in speaking of septic pylephlebitis, "The primary thrombosis is seen extending gradually and continuously or in short intervals of space upward toward the center, rarely involving the entire circumference of the lower course of the portal vein, but more commonly forming laterally adherent thrombi, alongside of which the blood current may pass with little interruption."

We would expect in cases of thrombosis of the portal and mesenteric veins infarction of the intestine, and as this has been rarely observed in these cases, it must be that the occlusion is generally not complete. I can find but few instances of post-operative thrombosis of the mesenteric artery or vein, except those cases associated with appendicitis. Delatour reports a case of venous thrombosis following splenectomy, and Mayland one, after gastrojejunostomy. Thrombosis of the hepatic artery is practically never recognized as a post-operative affection, although it must occur.

KIDNEY.

Thrombosis of the renal vessel following operation is very rarely recognized, but probably does occasionally occur. This

would be most likely to happen after resection of the kidney for tuberculosis, or incision through kidney substance for calculus. Embolism of the kidney, on the other hand, is much more frequent, being given by Ziemssen as occurring 57 out of 84 times in cases of peripheral embolism. Robinson says, "The general distribution of embolism following surgical operations is, relatively: (1) pulmonary, 70 per cent.; (2) renal, 12 per cent.; (3) splenic, 8 per cent.; (4) hepatic, 5 per cent.; (5) cerebral, 4 per cent.; (6) serous membranes (pleura peritoneum, joints, etc.), 30 per cent.

It is mainly due to the lodgment of emboli derived from the valves of the left heart and thrombi from the left heart and the aorta. By far the more common form of embolism is the septic or infective form. This is what we would expect, because in sepsis the heart, the chief seat of the source, is more apt to be involved. The lodgment of these infected emboli, which are usually of small size in the capillaries and smaller arteries, usually gives rise to metastatic abscesses and to acute suppurative nephritis. Where the emboli are small and are not infected, such slight and transient symptoms are produced that they escape recognition. Larger emboli, which plug the renal artery or its large branches, generally produce infarcts. The arteries are end arteries and the collateral circulation after their occlusion is very incomplete. The symptoms of an infarction of the kidney may readily escape notice unless the infarct be a large one or is infected. With large or numerous infarcts there is pain and tenderness over the kidney, with blood and hemoglobin in the urine. Where the emboli are infected, fever and other signs of sepsis are usually present and the urine may show changes indicating an acute suppurative process.

Israel, Simon, Johnson, Brewer, and others have emphasized the fact that in a large proportion of cases of hematogenous infections of the kidney, the lesion is unilateral, and give as a reason that there is a diminished resistance in that kidney as a result of a previous injury or disease, such as calculus, trauma, floating kidney, etc. This infection may, of course, take place without the occurrence of coarse emboli. Bacteria themselves may be transmitted in clumps and then be regarded as emboli, and the mere presence of pathogenic bacteria in the embolus does not necessarily impart to it infective properties. Welch says that he has seen in several instances in the spleen and kidney, only the mechanical bland effects

of emboli derived from the vegetation of an acute infective endocarditis, and has been able to demonstrate streptococci or other pathogenic organisms in the original vegetations and in the emboli.

SPLEEN.

From Litten's statistics emboli lodge not infrequently in the spleen, but very little can be found in the literature regarding post-operative thrombosis and embolism of the splenic vessels. Litten ranks splenic embolism with renal as the most frequent in the branches of the aorta. Ziemssen puts splenic embolism next to renal in his 84 cases, the number of cases being 39. Robinson gives it as constituting 8 per cent. of all post-operative cases. The symptoms are so indefinite unless infection is present that it may readily escape notice. The result of the lodgment of an embolus of considerable size is an infarction, and if the embolus is infective in nature or there is bacteriemia, an abscess is likely to result. The sources of the emboli are chiefly in the heart, either thrombosis of the cavities or more frequently endocarditis, which may result from the infection for which the operation is performed. Litten, in 35 cases of sepsis ending in death, found large tumors of the spleen without exception. Of these 35 cases, 14 of them had multiple abscess. He regarded these as the result of infarcts which were infected.

HEART.

The heart is the seat of thrombotic and embolic processes of the post-operative variety more frequently, perhaps, than is generally thought. As I have before stated, the vegetations of the cardiac valves are thrombi which are the chief source of embolism in the greater circulation. These are, perhaps always or nearly so, the result of infection. Thrombi form also in the cavities, especially the auricles, as a result of infection or a retarding of the blood current which results from chronic disease of either the valves, heart muscles, or a variety of chronic affections which produce cachexia or inanition. It is probable that the heart is the source of many of the post-operative pulmonary emboli whose origin cannot be discovered. A few cases of sudden blocking of the tricuspid or mitral orifice by an embolus have been reported. To me it seems remarkable that more emboli which eventually lodge in the pulmonaries do not stop, at least, temporarily in the heart. It is almost inconceivable that an embolus which will com-

pletely plug the pulmonary artery would pass through the heart without giving rise to well-marked symptoms, and it is possible that the high and irregular pulse which has been noted in many cases of femoral thrombosis may be due to small emboli passing through the heart.

Thrombosis and embolism of the coronary arteries may also occur, and should always be considered in looking for the cause of sudden death.

LUNGS.

The opinion is steadily gaining ground that a large part of the post-operative pulmonary complications are due to embolism. While a resident at the Johns Hopkins Hospital my attention was attracted by observations of cases and the study of our case histories to the relation existing between so-called pleurisies and thrombosis of the peripheral vessels, and I became convinced that the majority of cases which were diagnosed pleurisy were really pulmonary infarcts. In 1902 I published in *American Medicine* a paper upon this subject. Sonnenburg (*Verhand. Deutsch Gesell. Chir.*, Berlin, 1902) says that after laparotomies there occur inflammatory processes which have few symptoms and which can be defined only by careful observation and physical examination. In other cases the inflammatory processes are widespread pneumonic infiltrates which lie usually in the lower lobes, take the form of a severe pleurisy, or finally become localized lobular areas. In the course of years of observation he has come to the conclusion that most of these lung complications are of embolic origin. Albanus, who in 1,140 laparotomies saw 2 per cent. of recognized pulmonary embolism, found that at autopsies performed upon patients who during life had showed no symptoms of thrombosis, in many cases either a fresh lung embolus to be the cause of death, or where death was due to some other disease, a small pulmonary embolus or a pulmonary infarct, due to an embolus which had occurred after operation. I am certain that the statistics as to the frequency of this complication are much too low. However, Gebele, in 1,196 laparotomies, reported 14 cases of pulmonary embolism, Albanus found 2 per cent., Burkhardt in 236 myoma operations saw 12 cases, Pietrzikowski in 210 cases of incarcerated hernia saw 14 cases of what he considered to be pulmonary infarct. Byron Robinson reckons that 70 per cent. of all cases of post-operative embolism occur in the lungs. I believe I

am safe in asserting that with the technique practised to-day by our better surgeons, more deaths occur as a result of pulmonary embolism than any other one cause in operations for the removal of fibroid tumors and ovarian cysts. The origin of the embolus is usually a thrombus in the veins of the pelvis or lower extremity. The next most frequent source is probably the right heart, while any of the systemic or the portal system of veins may be the origin of the trouble. Being a result in a large majority of cases of thrombosis of the pelvic or femoral veins, it occurs more frequently, after operations for tumors of the uterus and ovaries in, strictly gynecological cases, while after operations upon the intestinal tract (including incarcerated hernia and appendicitis), the proportion of cases is large. Thrombosis of the pulmonary vessels occurs after operation, the majority of them being secondary to an embolus, while in a few cases the thrombosis may be the source of an embolus which plugs a small vessel.

BRAIN.

Embolism and thrombosis of the vessels of the brain are apparently rare complications of gynecological operations. Byron Robinson states that 4 per cent. of cases of post-operative embolism are cerebral. In my own experience I have encountered but two cases which I regarded as such. One occurred after a myoma operation, the embolus lodging probably in the left middle cerebral artery, producing transient hemiplegia and aphasia. The other case followed a curettage for retained secundines, and occurred in the retina. Byron Robinson also reports several cases in which he thinks from the symptoms that the embolism occurred into the floor of the fourth ventricle. I have been unable to find satisfactory statistics regarding these affections, but undoubtedly like other forms of these affections they are most likely to be the result of diseases of the heart and blood-vessels.