THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given George Ellsworth Sutton final oral examination for the degree of Master of Science in Surgery. We recommend that the degree of Master of Science in Surgery be conferred upon the candidate.

Minneapolis, Minnesota

May 23 1921

W B Bastrunck
Chairman

Louis B. Wilson

M. L. Henderson

H. E. Robertson

REPORT

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by George Ellsworth Sutton for the degree of Master of Science in Surgery. They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science in Surgery.

W E Bristrunk
Chairman

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7-20 2M

THESIS

Pulmonary Fat Embolism

George Ellsworth Sutton

Submitted to the Graduate
Faculty of the University of
Minnesota in partial fulfillment
of the requirements for the Degree
of Master of Science in Surgery.

June 1921.

Pulmonary fat embolism was first developed experimentally by Magendie in 1827 and was noted in the human by McGibbon in 1856. About the same time Virchow developed it experimentally in animals.(1) Up to and for some time following Schriba's (2) article on pulmonary fat embolism, this complication was looked upon as a pathological accident or curiosity. Schriba's article dealing with free fat in the blood-stream was the most comprehensive up to his time and for a long time following. His thoughts and deductions have quite dominated the literature on the subject since, this unfortunately, in a way, because some of his observations have been found to be in error or based on too little pathology, as was shown later by Warthin (3) and others. The foreign profession has furnished most of the literature and experimental work on fat in the blood-stream. Park(4) Graham(5) Warthin, Bissell(6) and Gauss(7) have furnished the bulk of the literature in this country.

Pulmonary fat embolism has, in the past, been most frequently noted in the fracture of bones. It is along this phase of the work that most has been written in conjunction with pulmonary fat embolism. Free liquid fat has been known for a long time to have been present in the blood-stream following injury to fatty tissue and the subsequent emboli of other organs observed. Just why the bulk of fat when put into the blood-stream should lodge in the lungs has always been a speculation. The experimental work has added considerable light on the subject (9) . The net-work or the capillary system of the lungs is long and tortuous, the surrounding supportive tissue is poor, and lastly, Gauss (7) has shown that by the simple addition of oil to blood the

viscosity of the blood is greatly increased, thereby slowing the blood-stream as it passes through the lung capillaries which are long and poorly supported.

From the observations of recent workers and more accurate attention being paid to pathology(7) , pulmonary fat embolism is a potential factor, at least, in the causation of death in any surgical operation where fatty tissue has been injured. It has been shown to be present following most any operation in the abdomen where the abdominal wall has been the approach, following removal of the mammary glands, both radical and simple, herniotomy, inguinal and ventral, removal of fatty tumors, thyroidectomy and any injury to bony tissue, especially where a fracture is present. Warthin also found it present following burns(3).

Investigators from the time of Virchow have experimented with the production of pulmonary fat embolism.(8). Fracture and crushing of bones has been one method, injury to fatty tissue has been another, and lastly, the injection of oils and fats directly into the blood-stream. This has been done by various investigators. The results have been quite uniform. The lethal dose of oil injected into a peripheral vein of a laboratory animal is 2cc per 1000 gm of body weight. The bulk of the oil injected intravenously soon collects in the lung capillaries. Reuter found as high as 62 to 68 percent of oil injected into a peripheral vein to lodge in the lung capillaries. Respiratory and circulatory disturbances are the first to be seen when small amounts of oil are injected into the blood-stream; the breathing increases in rate and becomes shallow. Coughing and dyspnea follow as the mount of oil is increased. In the circulation the pulse is quickened, the tension is lowered and cyanosis soon develops. As soon as the fat emboli pass through the pulmonary circulation small amounts may be found in the kidneys, spleen and other organs of the body.

Bissell (6) has shown very clearly the action of oil on the blood pressure when injected into the vein of a dog. He found an abrupt fall of arterial pressure and a simultaneous rise of venous pressure. This accounts for the small pulse in pulmonary fat embolism.

ETIOLOGY.

In the human there is normally from 0.5 to 0.85 percent of fat in the blood stream. This may be increased some by the ingestion of large amounts of fat. In some diseases the fat content of the blood is increased such as in diabetes mellitus, nephritis, tuberculosis, malaria, cholera, and also following poisoning by phosphorus and carbon monoxide. For the entrance of fat into the circulation in an increased amount to even approach the amount of free fat in the blood-stream as is found in pulmonary fat embolism there must first be some injury to the fatty tissue and secondly some solution of continuity of the blood-stream. Entrance of fat into the circulation by way of the lymphatics is not thought to be of much, if any, concern by most authors. (6). Once there is injury to the vascular system enough to take up this fat, there are several factors which make it easier to literally fill the blood-stream with free liquid fat. Incomplete hemostasis is particularly noticeable. Other noticeable factors are mobility of the injured parts, a weakened circulation, incomplete or shallow breathing, inhalation of lipoidal solvents and lastly, Bissel (6) would lead one to believe that some fat, from its gross appearance, is probably more readily taken up by the blood-stream than others.

That incomplete hemostasis is an important factor is shown by the fatal cases where operations have been performed on the abdominal wall. Almost without exception there has been found at autopsy a hematoma filled with fat droplets. The same may be said of operations on the breast which have

had a fatal outcome from pulmonary fat embolism.

That mobility of the injured tissue is an important feature is deserving of some consideration. To my mind this is probably the most important part in the etiology once there is an injury to the fatty tissue and a break in the venous or capillary circulation to take up the free fat. In the abdominal wall and in the chest wall there is free mobility depending on the rate of respiration. There are generally at least eighteen complete excursions per minute. These may be increased to forty or more. If there is a surgical excavation, and there usually is, this in turn produces a vacuum effect by forcing free fat into the opened blood-stream. Then, negatively speaking, in the Kondoleon operation where huge amounts of fatty tissue have been destroyed, not a death from pulmonary fat embolism has been reported. Here the limb is firmly bandaged and kept at rest for a period of at leat a week. Then, too, it was a common observation during the European war that a great many of the wounded especially the fractures that had to be transported any great distance before there was proper surgical interference, suffered from pulmonary fat embolism. This was quite easily detected. I noticed it particularly in one location. In the exigency of war two armies were placed side by side. We were just behind, drawing wounded from each. One army had ample splints to use, the other had none. Almost without exception the non-splinted fractures of large bones arrived in a very poor condition. The ordinary resuscitation methods aided these cases but little. Among the poorly-splinted cases the mortality was very high. I performed autopsies on eight fatal fracture cases and found an astonishing amount of fat in the lungs of all.

If the circulation is previously weakened the entrance of fat into the circulation tends to further weaken it. When fat enters the

venous circulation the venous pressure is increased and the arterial pressure decreased, consequently the blood flows at a slower rate. As has been shown by various writers (12) when free liquid fat enters the venous circulation the vast majority of it collects in the pulmonary capillaries. If there is incomplete aeration of the lung by shallow respiration the liquid free fat not only tends to remain there but more collects there as it enters the pulmonary circulation.

SYMPTOMATOLOGY.

This is of two types or a combination of both, pulmonary and cerebral. In the pulmonary type the chief symptoms are respiratory; the respiratory rate is increased and shallow, dyspnea soon develops, followed by cough and cyanosis; expectoration may be present and there may be blood in the sputum. The pulse rate is increased. The pulse pressure is low. The radial pulse is very small in a great many cases. These symptoms may come on exceedingly fast. In one case reported by Bissell(6) and operated by Doctor Judd, the respiratory symptoms began to appear during the operation. The amount of liquid free fat liberated into the blood-stream seems to determine the suddenness of symptoms. There is a type of case which seems to lie dormant or symptomless for a time and then have the respiratory symptoms appear at a later date. These symptoms may appear and then partly or wholly disappear only to reappear again in five to twelve days with a fatal result. (6). This is explained by some as being due to the fat passing through the pulmonary circulation out into the general circulation and again collecting in the pulmonary capillaries. The temperature is of two types: In the case confounded with shock we have a normal or subnormal temperature with a blanched or ashen appearance of the skin and mucous membrane. Too much emphasis has been laid on the temperature in pulmonary fat embolism (13).. It has been read into the literature in many instances that the rule is a normal or subnormal temperature.

In the majority of cases the temperature is elevated. In fact, it is quite the exception to have a normal or subnormal temperature. Out of the fatal cases in the Mayo Clinic since 1916, only two have had a normal temperature. Frequently previous to death there is a noted sudden elevation of temperature. When bloody expectoration is present it is explained by the rupture of some of the lung capillaries. This produces a hemorrhage into the bronchial tree, which hemorrhages are similar to the patches on the surface of the lung in the form of small petechial hemorrhages.

When the fat passes the pulmonary system and out into the general circulation the central nervous system may receive an overwhelming amount of fat in the form of emboli. When this occurs a cerebral chain of symptoms is seen, ushered in by restlessness, followed by headache, uneasiness, mental dullness, stupor and delirium. This delirium may vary from a mild type to a very disturbed state accompanied by hallucination. The reflexes are dulled and tremor, convulsions, and paralysis have been reported. Where the cerebral symptoms are predominant the diagnosis is often confounded with delirium tremens. The cerebral symptoms usually appear following the pulmonary symptoms, as a rule, from two to eight days following injury. (5,6,8).

For an aid in the diagnosis of fat embolism we have the following signs which are helpful and positive in a good many instances: Upon examination of the chest the lungs invariably show pulmonary edema; signs of broncho-pneumonia may be present at the bases. The right heart is usually dilated. Small petechial hemorrhages may be present in the skin over the chest. The sputum may be blood stained, and may contain numerous fat droplets. These can be readily detected grossly. They can also be easily stained by any fat stain. Fat droplets in the sputum appear early. This is one of the newer signs of

pulmonary fat embolism and should not be overlooked. Warthin(3) found them as early as the second day following injury. At autopsy it is common to find fat droplets in the mucous exudate of the trachea and large bronchi. Along with the fat droplets in the sputum there may be alveolar cells and phagocites containing fat droplets. Fat globules may be present in the urine. This is easily detected by holding the urine up to the light and looking for small or large fat droplets on the surface. The lipuria may appear at once. It usually appears at some time during the complication but deaths from fat embolism may occur without any lipuria at all. This is explained by the lung tissue holding a sufficient amount of fat to cause death without forcing any free fat into the general circulation. In addition to the lipuria, casts may be present; some observers report a brownish cast present. (14). In some instances free fat may be obtained in the general circulation by vena puncture.(15) By examination of the eye-grounds fat may be seen circulating in the retinal vessels.(16).

In explaining the difference between pulmonary fat embolism and shock a good many authors state that there is a quiescent period in pulmonary fat embolism before symptoms appear.(17). This is true in some instances, but in others the symptoms and signs may appear during the operation or, if an injury, immediately following the injury.

PATHOLOGY.

The pathology of pulmonary fat embolism is first of all a lipemia, with a subsequent distribution to the tissues, principally the lung, of emboli of liquid fat. This takes on the role of infarction in the tissues of the body when it leaves the lungs. These infarctions go through the same pathologic change that an infarct does in the same tissue caused by any foreign material. In a wound in the fatty tissue, filled or partly filled with blood-

clot and loaded with free fat droplets, this would seem to be an ideal way of feeding the venous system with fat. The richer the area is in fat the more can be distributed to the blood-stream.

In the lungs we find the capillaries filled with fat droplets. Fat may be present in the small veins of the lung tissue and free fat droplets may be seen in the trachea, large bronchi and, in some instances, in the smaller bronchi. Often the capillaries of the lungs are ruptured, allowing the escape of the fatty foreign material with localized small areas of hemorrhage. This is particularly noticeable on the surface of the lung where small petechial hemorrhages, which may be red or rusty brown in color, depending on the age of the hemorrhage, are seen. The lung shows considerable engorgement of blood. Edema, localized or quite general, is present and in bodies dead of pulmonary fat emboli there is generally a broncho-pneumonia in the lower lobes. When the lung tissue is cut fat droplets are seen on the blood that runs from the cut surface. The liver, spleen, heart and adrenals show fatty infarction with fatty degeneration of the tissue involved(15). Grossly the kidneys show congestion. On staining for fat, the capillaries show fat emboli. This is especially true of the capillaries of the glomeruli where showers of fat are to be seen. Accompanying the fat in the capillaries of the glomeruli there may be areas of hemorrhage.

NERVOUS SYSTEM.

It is the consensus of opinion that the involvement of the nervous system is a later phase of pulmonary fat embolism(6). There is no particular part of the central nervous system where fat emboli have not been found. Fat is present in the retinal vessels, in the capillaries of the grey and white matter and in the capillaries of the cord. Fat is often seen in the perivascular

spaces of the vessels in the central nervous system. Edema of the nervous tissue adjacent to the emboli is a frequent occurrence.

Wilms is of the opinion that a considerable quantity of fat in the blood-stream which subsequently lodges in the lungs and other organs, comes by way of the lymphatics(17½). Upon this theory he inaugurated the treatment of draining the thoracic duct in pulmonary fat embolism. The lymphatic system plays some small part in the transportation of fat in fat embolism but it is not the principal channel of transportation. The lymph nodes adjacent to a wound producing pulmonary fat embolism may show no fat at all. Experimentally the lymphatics of a limb may be removed as freely as possible and the fat transferred to the lungs as freely as ever by injury to the limb. (18.)

TREATMENT.

Preventive: Where bones are broken or crushed the member should be kept quiet(19). If transportation is demanded, the fractured member, if it is an extremity, should be put on an extension splint. The use of an Esmark bandage has been recommended as well as Momberg's belt for a half hour following fractures about the pelvis(20). The use of lipoidal solvents in wounds should be avoided. Complete hemostasis is important and in cases where considerable fatty tissue has been injured, the wound should be drained at its dependent point.

Active treatment has not met with much success. Normal saline injected into the veins has been recommended.(21) Shanz reports good results in the treatment of eight cases by this method(22). He injects the solution early into the several veins, preferably into a large vein. A two percent solution of sodium carbonate has been recommended by Czerny; Miniuch

thinks it useless(23). Experimentally it does relieve the dyspnea. Wilms recommends drainage of the thoracic duct. In one case so treated the patient recovered(17½).

Remembering the extra strain put on the right heart by the increased resistance in the pulmonary circulation, one should use intravenous medication in small amounts. If large amounts of intravenous solution are to be given either with an attempt to dilute the blood-stream or to "fix" the oil as in the use of sodium carbonate it would be better to precede such treatment with venesection. Stimulation and supportive treatment should be undertaken. Cardiac stimulants and heat should be applied to keep the blood-stream flowing at as high a rate as can be maintained.

Following is a resume of the cases of pulmonary fat embolism that had a fatal ending in the Mayo Clinic. These cases date from the year 1916 and do not include the three cases reported in 1917 by Bissell.

Case A 185831

Autopsy 88

Age 31 years

Weight 175 pounds

Height 5 feet, 3 inches

Diagnosis Left inguinal hernia

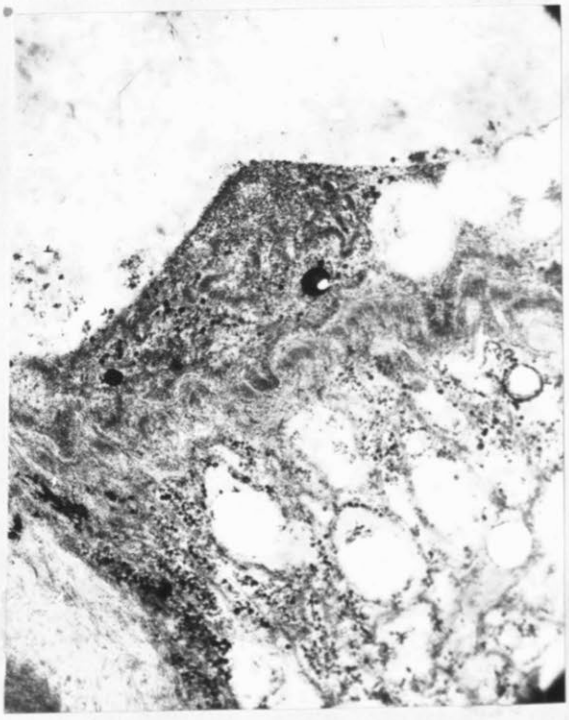
Operation: Sac excised, stump Kocherized, cord transplanted; closed with chronic catgut; large piece of scarred omentum (operative note); poorly developed muscle. Great deal of fat and large hernial opening.

Post-operative notes: Had some gas pains post-operatively. Discharged from hospital on tenth day. Wound healed following operation. Temperature 102 for two days; pulse 112 for three days. Temperature 99 on fourth day; normal on eighth day. Pulse gradually decreased to normal on eighth day. On second day following dismissal from hospital patient began to show evidence of partial bowel obstruction; abdomen distended with gas; no vomiting; very little relief from enemas. Readmitted to hospital five days later (17 days post-operative); abdomen reopened and explored. At operation all small intestines seen were distended, sigmoid and transverse colon collapsed. There was free fluid in the abdominal cavity. Piece of scarred omentum causing obstruction was removed.

In the afternoon following second operation temperature and pulse elevated; pulse weak. Pulse rate increased and became much weaker during night. Patient became clammy, cyanotic and restless. Temperature 103.5 (axillary); pulse 140, irregular. Coarse rales noted over chest. Death occurred twenty-four hours after second operation.

Autopsy Findings: Hernial operation scar 12 cm long; low midline scar 16 cm. long; petechial hemorrhages over false pelvis; patches of semi-consolidation in lower lobe of right lung intermingled with edema; large amounts of free fat in large and small globules found in blood of the cut surface of the lungs.

It is my opinion that this case suffered from pulmonary fat embolism following the first operation and seemed well on the road to recovery after the sixth day post-operative. The necessity for a second operation with more injury to fatty tissue and a lessened vitality added sufficient fat to the circulation to produce a fatal issue.



Case 185831 Showers of fat droplets in capillaries and larger vessels of lung. Numerous fat droplets in alveoli.

Case A 193911

Autopsy 163-17

Age

Weight

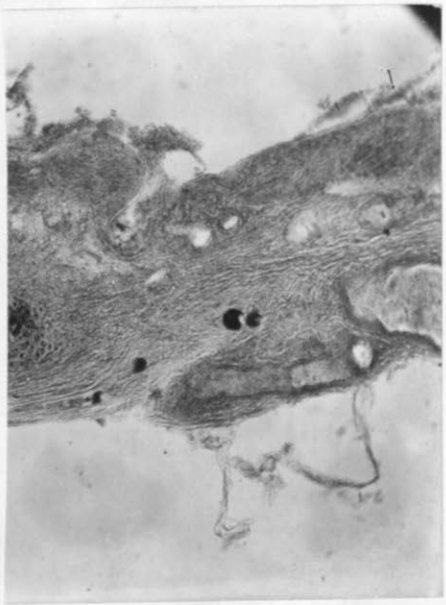
Height

Diagnosis Gall-stones, commond duct obstruction, obesity

Operation, Choledochotomy; cholecystectomy

Autopsy findings: Large intra-peritoneal hemorrhage; petechial hemorrhages over visceral pleura; muco-hemorrhagic tracheo-bronchitis; pulmonary fat embolism; blood and serum covered with fat droplets in operative wound. Death fifteen hours post-operative.

It is perfectly evident that this is not a death from pulmonary fat embolism but one of post-operative hemorrhage. Pulmonary fat embolism is present in a fair degree. I report this case to show again how rapidly fat travels to the lung capillaries. Death occurred fifteen hours post-operative and on examination of the lungs at autopsy we find an appreciable amount of fat lodged in the pulmonary capillaries.



Fat present in a few vessels of the lung.

Case A 265230

Autopsy 194-19

Age

Weight 160 pounds

Height

Blood pressure 120-70

Diagnosis Carcinoma of stomach? Findings-subcutaneous tissue soft and flabby

Operation Cholecystectomy; excision of duodenal ulcer; pyloroplasty; three rubber tissue drains through stab wound.

Operative findins: acute perforation of gall-bladder forming a mass well to the right of the midline; large number of stones and foul material in gall-bladder; extensive ulcer of duodenum.

Respiration while on table 40-44; pulse 80-100.

Death fourteen hours post-operative, cardiac insufficiency; pulse very weak- did not respond to camphorated oil, adrenalin, atropin, morphin, digitalis or intravenous saline; pulse 90-65; temperature 97.5--98.5

Autopsy Findings: Subcutaneous fat 3 cm in thickness; on opening the pulmonary artery the blood contained a great amount of free liquid fat in the form of droplets; the same was found in the blood of the right heart; there were petechial hemorrhages on surface of lung measuring 5 mm. in diameter and some of them coalescing to form larger patches of gelatinous hemorrhage, in all respects resembling fatty infarction.

Case A 202891

Autopsy 276-17

Age 52 years

Weight 200 pounds

Height 5 feet, 7 inches

Blood Pressure, 146-72

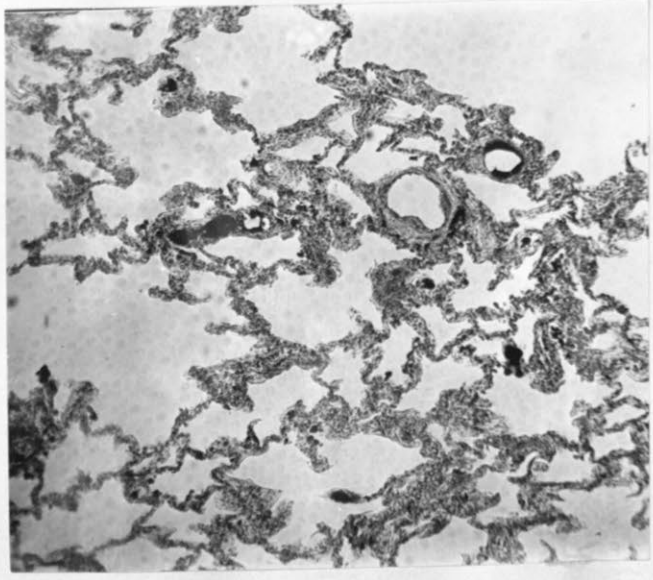
Note on surgical card "Very fat"

Diagnosis: Submucous fibroids

Operation: Subtotal abdominal hysterectomy

Post-operative notes: Left operating-room in good shape. On evening of first day pulse elevated to 90, temperature 99; on second day, pulse 100, temperature 100; on third day, pulse 120, temperature 103.8. Hospital note on fourth day post-operative: Facies of peritonitis; pulse rapid; temperature up, very weak, cold and perspiring".

Autopsy Findings: Subcutaneous fat over abdomen 3.5 cm. thick. The great omemtum contained a large amount of fat; the lower end of great omentum showed evidence of trauma; the skin was pale, fat droplets were present in considerable quantity in the blood of the inferior vena cava; the lungs were similar posteriorly; there was an uneven distribution of bright red petechial hemorrhages on the surface of the lungs, some measuring 3 mm. in diameter. There were free fat droplets in the blood of the portal vein. Fat was scattered throughout the lung tissue on microscopical examination.



Capillaries and larger vessels filled with fat. In this case there is but little fat in the alveoli.

Case A 192661

Autopsy 135-17

Age 52 years

Weight 225 pounds

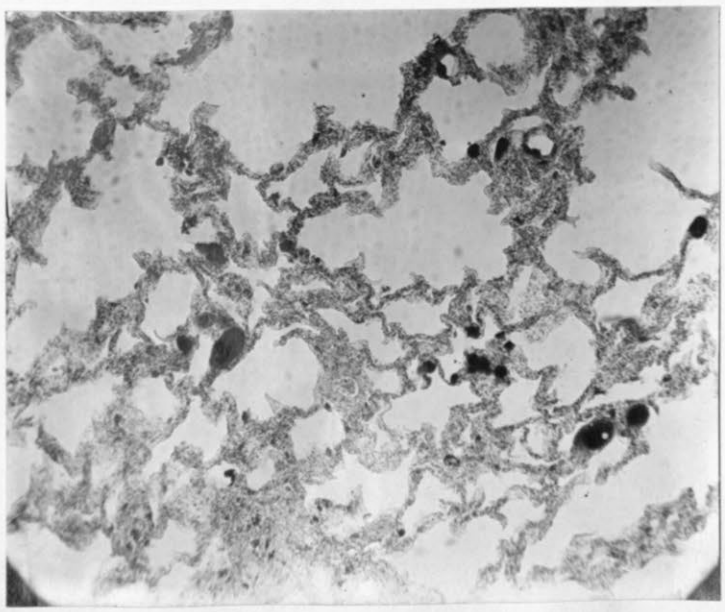
Height 5 feet, 3 inches

Diagnosis: Incarcerated umbilical hernia; obesity
Physician's resume: ventral hernia-emergency; not a good risk

Operation Herniotomy; adherent omentum separated; segment of omentum removed; plastic closure.

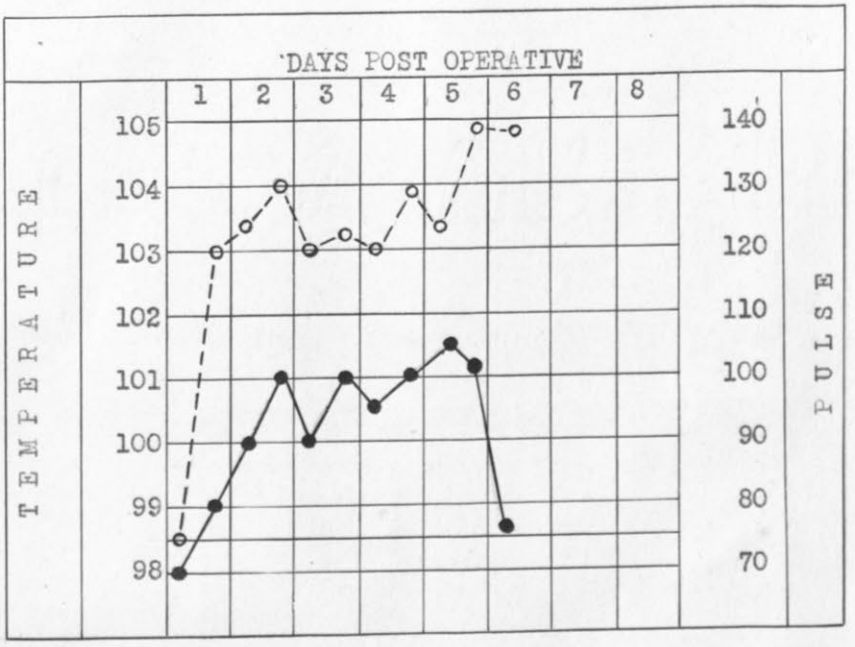
Post-operative notes: On second day post-operative temperature rose to 100; Pulse 120. Pulse remained between 120 and 130 for five days, then increased to 140 on the sixth day. Temperature remained between 100 and 101 for four days, then dropped to normal on sixth day. W.B.C. was 5600; P.M.N. 46.7, small lymphocytes 51.7, large lymphocytes 1.0, eosinophiles .7; The urine contained R.B.C. 1 on a scale of 4.

Autopsy Findings: Extremely obese, weight about 225 pounds, height 5 feet, 3 inches. The abdominal wound contained a blood-tinged material rich in fat droplets; the fat over the abdominal wall measured 4.5 cm in thickness. There was an amputation of part of the great omentum at autopsy. The vessels of the neck were ligated. On opening the aorta fat droplets were found in the blood of the vessel. Fat droplets were also found in the inferior vena cava. The lungs were hyperaemic and fat droplets were present in the blood from the cut surface of the lung.



Capillaries and vessels of larger size filled with fat.

192661



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Pulse – – – – –

Case A 176352

Autopsy 319-16

Age 44 years

Weight

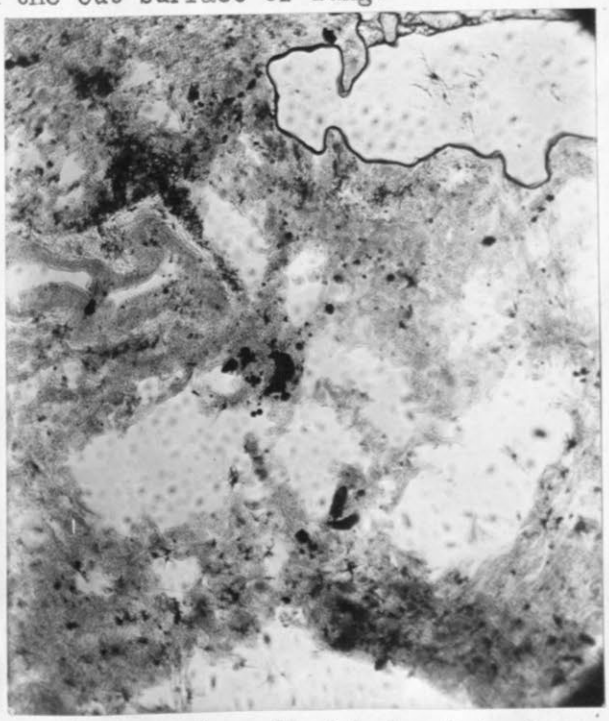
Height

Emergency Case: injury in railroad accident; transported 35 miles by rail no splinting.

Diagnosis: Fracture amputation lower third of left leg; contused wounds of right leg and toes; midline scalp wound; contusion of right and left cheeks; large hematoma of back (lumbar region)

Operation: Wounds dressed; 32 ounces normal saline given intravenously. Death same day.

Autopsy Findings: Anatomic diagnosis- traumatic amputation of left leg; multiple fractures of pelvis. Hemorrhage into retroperitoneal tissue; contusion of mesentery; hemorrhage in left pleural cavity; toes of right foot crushed; bright red petechial hemorrhages on surface of lungs; fat droplets in blood of inferior vena cava and pulmonary artery; fat droplets in substance expressed from the cut surface of lung.



Large and small fat droplets in the vessels and alveoli of lung.

Case A 108053

Autopsy

Age 56 years

Weight 150 pounds

Height

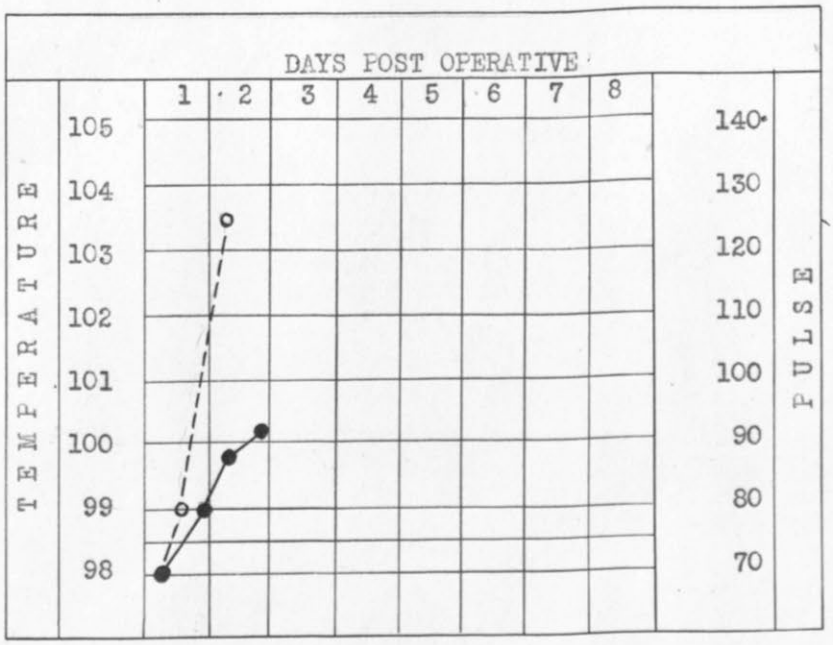
Diagnosis: Large abdominal hernia

Operation: Plastic closure of hernia; extensive dissection of fatty tissue; no drain. Surgeon's note: hernia large; difficult to close.

Post-operative notes: Temperature elevated on first day post-operative to 99. Second day to 100. Pulse 90 first day post-operative; 126 second day. Death on second day post-operative.

Autopsy Findings: Abdomen negative except for operative wound on abdominal wall. Petechial hemorrhages over the surface of the lungs; fat emboli extensive in lungs; fat droplets in the mucous exudate of trachea and bronchi.

108053



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Pulse— - - - -

Case A 212639

Autopsy 291-17

Age 9 years

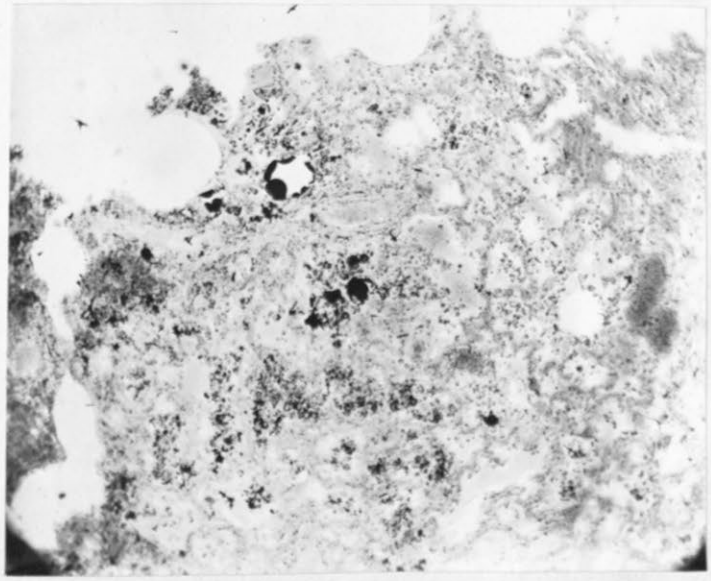
Surgical Diagnosis: Fracture of right leg(lower end of femur with sequestrum)

Operative Diagnosis: Traumatic separation of epiphysis; compound fracture post-operative of right leg with mal-position; end of femur protruding through operative scar; end of femur necrotic.

Operation: Granulation tissue curetted; skin edges removed around old infected scar for a distance of one-fourth inch; ends of bone freshened; epiphysis replaced and held by two nails; wound left open; plaster of paris splint applied. Time of operation, 50 minutes.

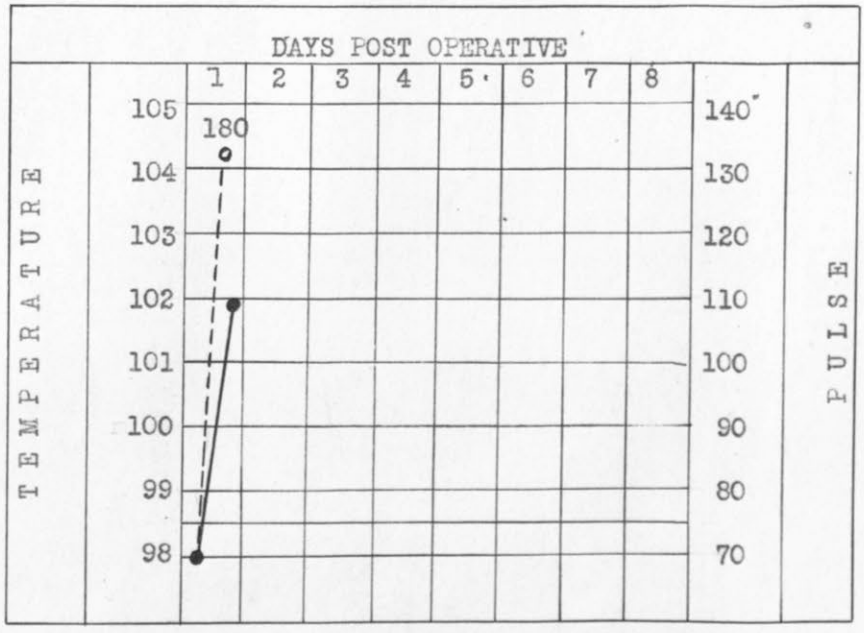
Post-operative notes: Patient returned to room in pulseless condition; pulse at end of operation 120; increased to 180 six hours later; temperature at end of operation 98; elevated to 102 six hours later. Patient died 8 hours after operation. Diagnosis: Surgical shock.

Autopsy Findings: Large fat globules, some very large, in vessels of lungs; fat globules diffusely scattered throughout lung parenchyma.



Showers of small fat droplets in the lung capillaries and mucous exudate of alveoli. Note: The large sized vessels are filled with fat.

212639



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Pulse – – – – –

Case A 268997

Autopsy

Age 59 years

Weight 220 pounds

Height

Diagnosis: Tumor of left thigh

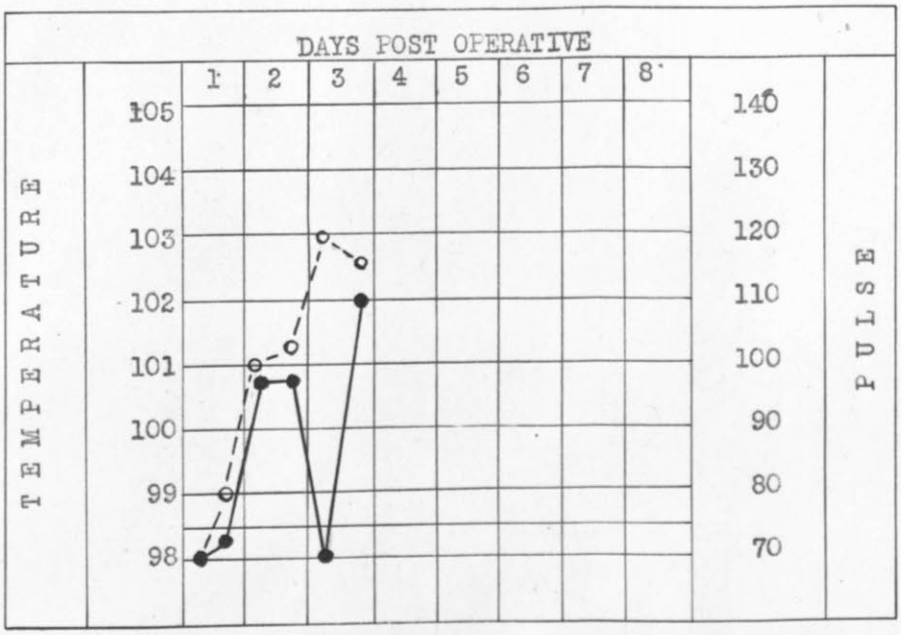
Operative Diagnosis: Lipoma inner aspect of left thigh; weight 7¼ pounds.

Operation: Enucleation of lipoma

Post-operative notes: Death occurred on third day post-operative, with pulse 120, temperature 102.

Autopsy Findings: Incision 30 cm. long with a drain at its lower angle; bilateral pulmonary fat embolism in large quantity; no other findings except a local wound infection which took on a subcutaneous gas dissection; this was post-mortem and not noted before death.

268997



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Pulse - - - - - -

Case A 168252

Autopsy 522-20

Age 60 years

Weight 229 pounds

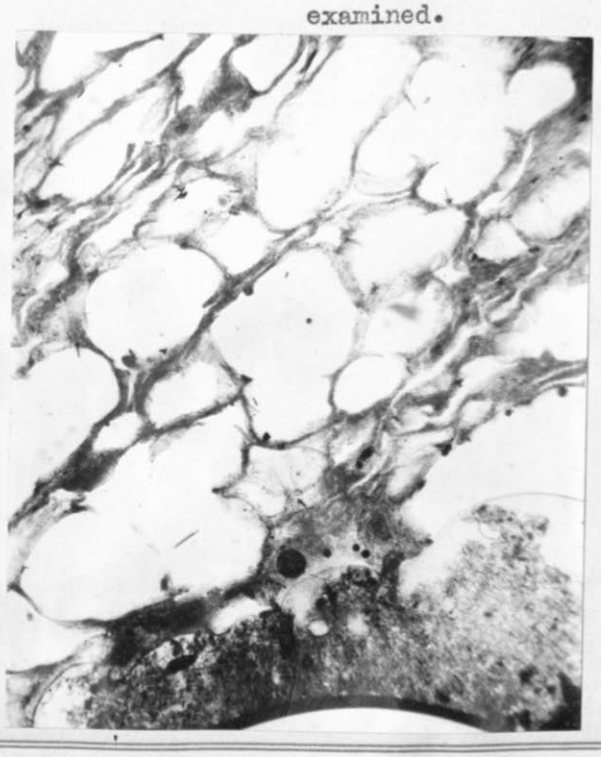
Height

Diagnosis: Post -operative ventral hernia.

Operation: Overlapping hernial repair; hernial opening large and closed with considerable difficulty. It was necessary to dissect a large area of fatty tissue in order to procure proper flaps. Ether was used in wound for cleansing purposes. Ether anesthesia.

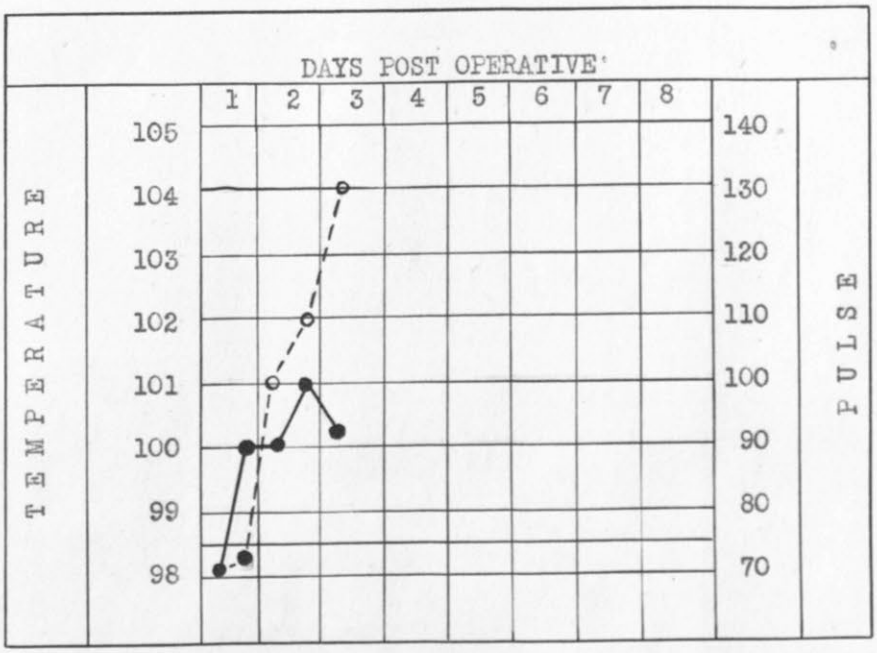
Post-operative notes: Returned from operating-room in good condition; in afternoon of first day temperature elevated to 100; pulse 100; breathing shallow with an increased rate of 40; breathing labored, pulse became weaker, faster and irregular; some cough. Cyanosis developed on second day. Lung findings-rales of mucous type over both lower lobes posteriorly; hands cold. Death occurred on third day.

Autopsy Findings: Abdomen negative except for operative wound on abdominal wall; wound undrained and contained a moderate amount of unclotted serosanguineous fluid covered with free fat droplets; the lungs showed a passive hyperaemia in the dependent portion, with an edema. The blood expressed from the cut surface of the lung showed a large amount of free fat droplets floating on the surface. Brain not examined.



Large and small fat droplets in the capillaries and alveoli of lung.

168252



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Pulse - - - - - -

Case A 186135

Autopsy 86-17

Age 31 years

Weight 142 pounds

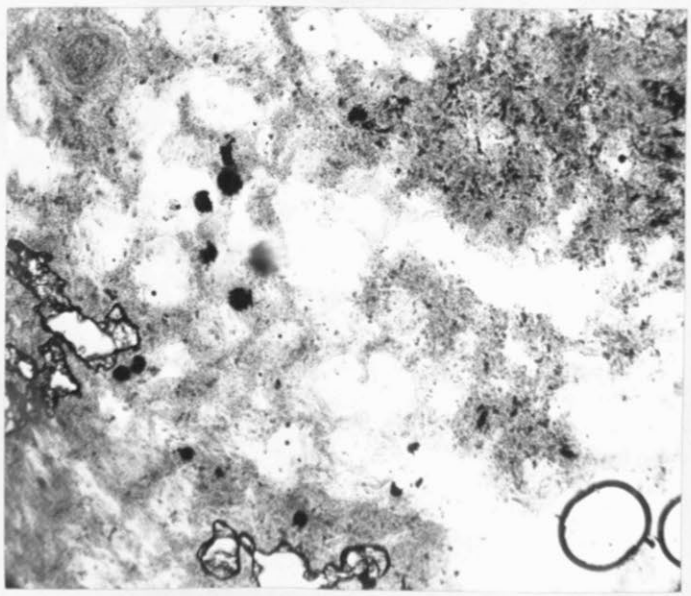
Height 5 feet, 6 inches

Diagnosis: Spinal cord tumor

Operation: Removal of arches of fourth, fifth, sixth and seventh dorsal vertebrae.

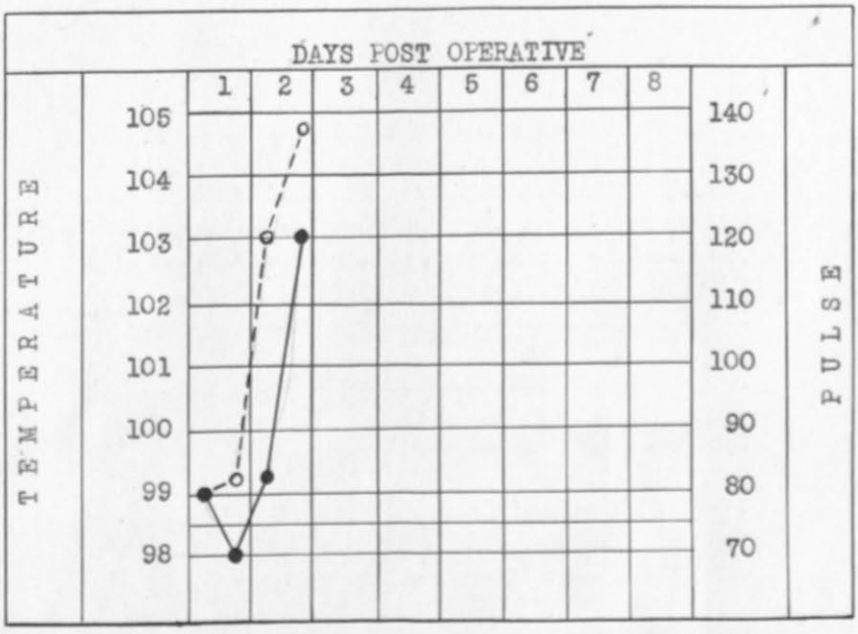
Post-operative notes: Temperature elevated to 103.8 on second day, pulse 135; death occurred on second day.

Autopsy Findings: Marked pulmonary fat embolism; marked hypostatic hyperaemia of both lungs: marked edema of the brain. On the posterior visceral pericardium near the base of the heart and great vessels and in the capsule of the liver there were many small petechial hemorrhages; operative wound contained bloody serum with muscle free from fat.



Capillaries filled with fat droplets.
Some larger vessels filled with fat.

186135



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Pulse - - - - -

Case A 179570

Autopsy 359-16

Age 28 years

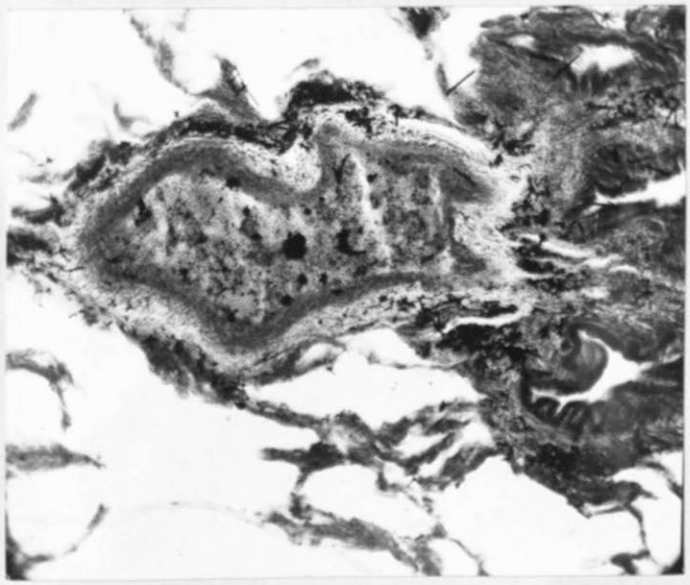
Weight

Height

Diagnosis: Compound fracture of both femurs and left humerus; scalp wounds; contusions over body.

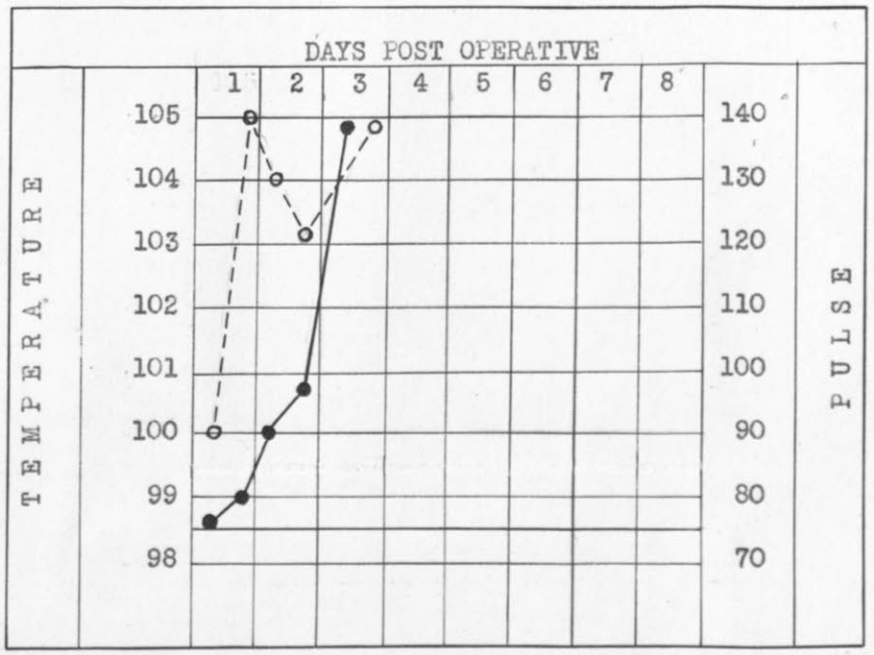
Hospital notes: Patient put to bed in state of shock; pulse 140, respiration 18, temperature 99; wounds cleaned; fractures supported by splints; temperature on second day 100.6, pulse 120; temperature on third day 105, pulse 140; death occurred on third day.

Autopsy Findings: Abdomen negative; 150 cc. of blood-tinged fluid in each pleural cavity; lungs were dissimilar; lower lobe of right lung very heavy compared to the lower lobe of left lung; in the interlobar fissures there were many petechial hemorrhages, the largest being 3mm. in diameter. On sectioning the lung fine fat droplets could be seen running from the cut surface; similar fat droplets could be seen in the blood of the inferior vena cava.



Exudate of bronchus with considerable fat present.

179570



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Pulse - - - - -

Case A 191362

Autopsy 133-17

Age 67 years

Weight 160 pounds

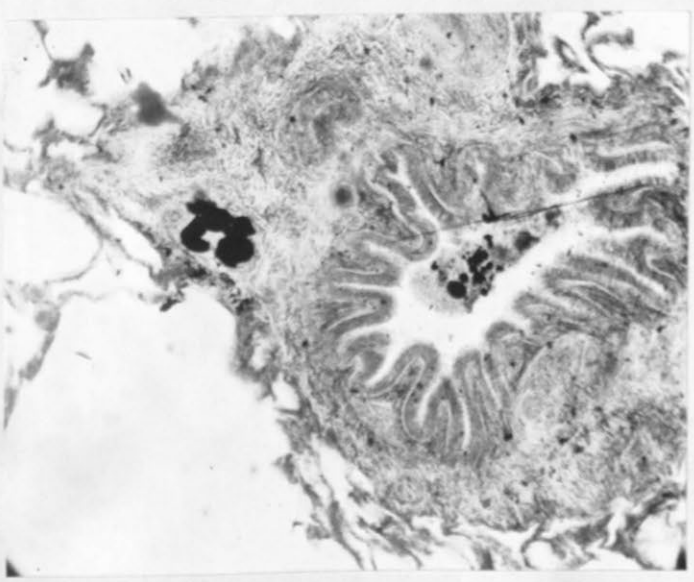
Height 5 feet, 8 inches

Diagnosis: Post-operative ventral hernia

Operation: Plastic repair of hernia; removal of spermatocele

Post-operative notes: Temperature on second day 99.5, pulse 80; temperature on third day 101.8, pulse 105. On fourth day had some bloody sputum; moderate cough. On fifth day bronchial breathing at base of right lung with numerous moist and crackling rales. Pulse remained at 100 to 110 until ninth day, then rose to 120. Temperature came down to normal on fifth and sixth days; elevated on seventh day to 102; normal again on eighth day; elevated to 100 on ninth day and remained between 100 and 102 until eleventh day post-operative, when death occurred. The W.B.C. on the sixth and tenth days was 6000. The sputum was negative for tuberculosis on three examinations.

Anatomic Diagnosis at Autopsy: Pulmonary fat embolism; petechial hemorrhages over the visceral pleura posteriorly; edema of lungs; large hematoma of operative wound; obliterative fibrous pericarditis.



Large vessels as well as capillaries contain fat. Note fat droplets in the exudate of bronchus.

Case A 176353

Autopsy 318-16

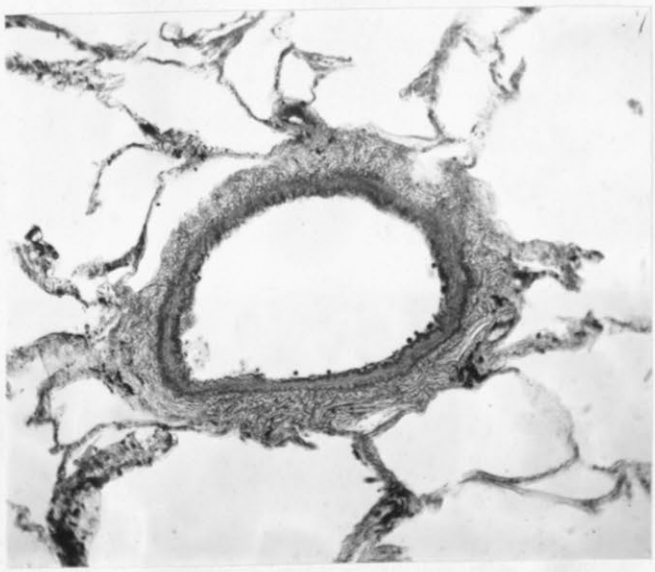
Age 75 years

Weight

Height

Emergency case: Injury in railroad accident; transported 35 miles by rail, on cot; received in hospital in moribund state; grew steadily worse and died two hours later.

Anatomic Diagnosis: Broken back, compound comminuted fracture of both bones of left leg; multiple fractures of pelvis; fractures of first second, third, fourth and fifth ribs; fracture of lower jaw; large amount of liquid fat in inferior vena cava and in chambers of right heart and pulmonary artery; large amount of liquid fat in lying parenchyma.



Section through a large vessel showing small fat droplets. From the size of the vessel this is probably the amount of fat that is free in the blood stream.

Case A 181050

Autopsy 395

Age 42 years

Weight 278 pounds

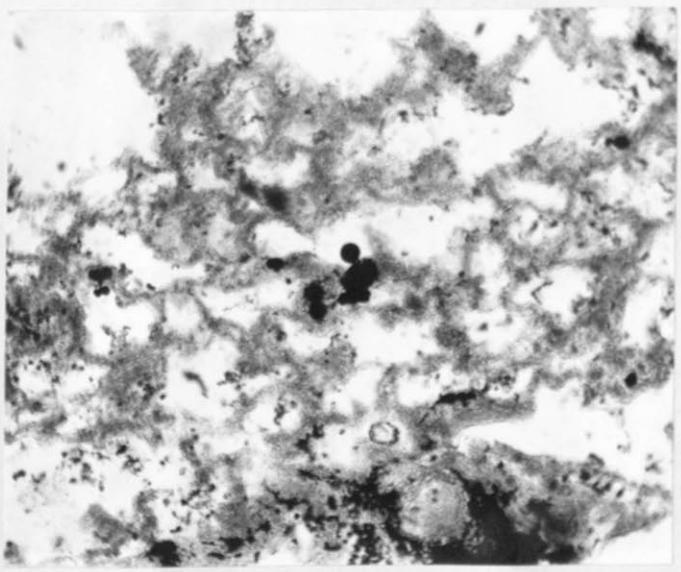
Height 6 feet

Diagnosis: Multiple adenomata of thyroid with marked obesity

Operation: Thyroidectomy: During the operation there was difficulty in breathing. The trachea was opened and breathing became better; operation was completed and breathing was so good that trachea was closed.

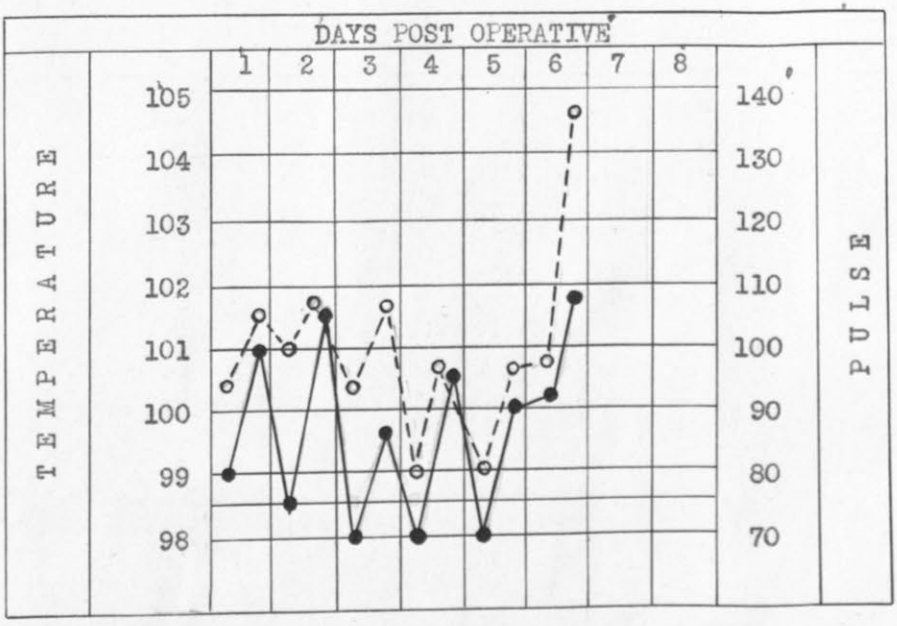
Post-operative notes: Left operating-room in good condition. On third day became mentally disturbed and on fourth day became delirious: pulse elevated and very weak. Death occurred on sixth day post-operative.

Autopsy Findings: The parietal pleura was negative; over the visceral pleura posteriorly and in the interlobar fissures there were a few red and fading brownish red petechial hemorrhages; there was an unusual amount of blood in the lung parenchyma; free fat droplets were present in this blood when expressed. There were no areas of consolidation in the lungs anywhere. The upper respiratory passages were free; there was no inflammation in the mediastinum.



Showers of small fat droplets filling the capillaries of lung. The larger vessels quite filled with fat.

181050



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Pulse - - - - - -

Case A 202195

Autopsy 269-17

Age 50 years

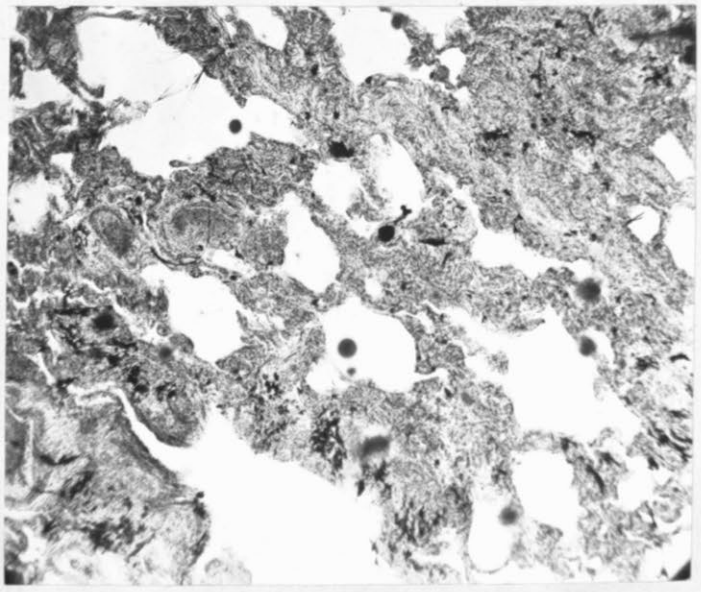
Weight 147 pounds

Height 5 feet, $3\frac{1}{2}$ inches

Diagnosis: Carcinoma fundus uteri?

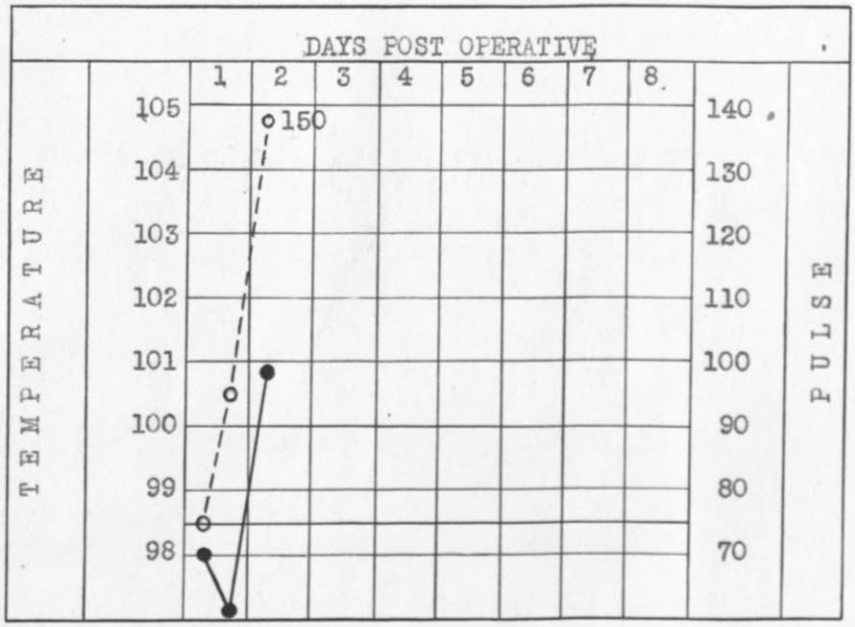
Operation: Total abdominal hysterectomy; Death 20 hours post-operative.

Autopsy Findings: Negative except for pulmonary fat embolism; blood-tinged mucus of trachea and large bronchi which was rich in fat droplets.



Large sized fat droplets in vessels of lung. Large sized fat droplets in alveoli of lung. One would expect to find fat droplets in the sputum in a case like this.

202195



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Pulse. - - - - - -

ANALYSIS OF CASES DYING FROM PULMONARY FAT EMBOLISM

Operation or Injury	Age	Weight	Height	Temperature.	Pulse	Onset of Symptoms	Result	Clinical Diagnosis	Distribution of fat(at autopsy)
A202195,total abdominal hysterectomy.	50	147	5'3"	105	100	at once	death 20 hrs.	shock	Lungs:mucus of trachea & bronchi.
A202891,total abdominal hysterectomy	52	200	5'7"	103.8	120	8 hours	death 5th day		Lungs:inf.vena cava; portal vein
A168252,post-operative ventral hernia	60	229	-	99-100	130	8 hours	death 3rd day	pul. fat embolism	Lungs
A108053,ventral hernia	-	-	-	99-100	99-126	12 hours	death 2nd.day	pul. fat embolism	Lungs:mucus of trachea & bronchi.
A192661,umbilical hernia	53	225	5'3"	100-101	100-130	2nd day	death 6th day	pul. fat embolism	Lungs:inf.vena cava;blood of aorta
A191362,ventral hernia	67	160	5'8"	100-102	80-120	2nd day	death 11th day	pneumonia	Lungs:
A268997,tumor of thigh	59	-	-	101-102	100-120	12 hours	death 3rd day	pul. fat embolism	Lungs.
A181050,partial thyroidectomy	42	278	6'1"	99-101.5	80-100	at once	death 6th day	cardiac dilation	Lungs.
A185831,inguinal hernia	-	175	5'3"	103.5	100-140	at once	death 1st.day	intest. obstruction	Lungs.
A265230,cholecystectomy	59	160	-	98.5	90-120	on table	death 12 hrs.	cardiac insufficiency	Lungs:rt.heart; pul. artery

ANALYSIS OF CASES DYING FROM PULMONARY FAT EMBOLISM(cont'd)

Operation or Injury	Age	Weight	Height	Temperature.	Pulse	Onset of Symptoms	Result	Clinical Diagnosis	Distribution of fat(at autopsy)
A186135,Laminectomy	31	142	5'6"	103.8	135	1st.day	death 2nd.day	Meningitis	Lungs
A179570,multiple fractures	28	-	-	99	140	1st.day	death 3rd.day	Shock	Lungs:inferior vena cava.
A212639, fracture	9	-	-	102	120	at once	death 8 hrs.	Shock	Lungs
A176353,multiple fractures	75	-	-	-	-	at once	death 2 hrs.	Shock	Lungs:rt.heart inf. vena cava
A176352,multiple fractures	44	-	-	-	-	at once	death 1st.day	Shock	Lungs:pul. artery inf. vena cava
A193911, cholecystectomy	-	Obese	-	-	130	-	death 15 hrs.	-	Lungs

Summary

There are several things to be learned from the analysis of these cases. One thing that stands out is that an obese person undergoing any major surgery and especially if there is of necessity a destruction of fatty tissue, carries an added risk. In the vast majority of cases the symptoms of pulmonary fat embolism appear suddenly. They may develop during the operation. A differential point between shock and pulmonary fat embolism made by some authors is that the symptoms of pulmonary fat embolism make their appearance at a later date. This, as shown by our series of cases, is not necessarily true.

Death from pulmonary fat embolism is relatively rapid as shown by these cases, the large majority of which were fatal on the first, second and third days following operation. Only one patient lived to eleven days, and the next longest is six days.

A positive diagnosis was made in four instances, with three other doubtful diagnoses. In one case (202195) the surgeon inserted a glass tube with gauze into the wound to prevent the absorption of fat. Even with this preventive measure the patient died in twenty hours of pulmonary fat embolism.

The temperature in all cases here reported is elevated.

This series of cases together with the three cases reported by Bissell represent the fatal cases of pulmonary fat embolism which have occurred in the Mayo Clinic since 1916. These cases were all proved by autopsy. Two cases, a gall-bladder case and the other a hysterectomy, had all the clinical symptoms of pulmonary fat embolism but an autopsy was not permitted.

Stimulative treatment and intravenous normal saline seemed to have but little effect in the cases in which they were administered.

Pulmonary fat embolism is to be taken into consideration as a complication in any surgical case where there is destruction of fatty tissue and where symptoms of cyanosis, rapid or labored respiration with or without a cough, elevated temperature and an increased pulse with a low tension appear. The sputum, urine and the eye-grounds should be investigated for fat.

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