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Early postoperative ambulation and its relation to pulmonary embolism

Alvin Katsman
University of Nebraska Medical Center

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EARLY POSTOPERATIVE AMBULATION
AND ITS RELATION TO PULMONARY EMBOLISM



By

Alvin Katsman

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DEFINITION OF EARLY AMBULATION

Early postoperative ambulation may be defined as walking on or by the first to third postoperative day. Nelson (1944) feels that the term "early" means rising within the first 72 hours following surgery. Leithauser, a leading proponent of early ambulation, said in 1943, "I now mean that the patient is to be out of bed by the first postoperative day, and only in rare instances by the second". Newburger (1943) defines early ambulation as walking within the first 24 hours post-operatively. He says the term includes daily postoperative self care in toilet, dressing, feeding, and even gymnastics. Deep breathing and leg exercises are recommended if walking is contra-indicated for any reason. Keyes (1947) defines early rising as walking on the first or second postoperative day. Zimmerman (1938) is of the opinion that the patient should remain in bed one to three days. Henriksen (1941) believes that ambulation is early if it begins on the third or fourth day. Portis (1936) says the patient should be out of bed by the fourth to sixth day.

HISTORY OF EARLY AMBULATION

Confining surgical patients to their bed for long periods of time is a tradition handed down from James Hilton in 1861 among others. Though credit is usually given to Emil Ries for being the first to publish a paper advocating early ambulation, there were undoubtedly many surgical patients before this time who rose early. Nixon (1944) says that actually early postoperative walking began in 1809 with the first laparotomy performed. Ephriam McDowell, when he visited Mrs. Crawford on her fifth postoperative day remarked, "Much to my astonishment I found her engaged in making up her bed".

Ries published his "Some radical changes in the after-treatment of celiotomy cases" in 1899. The change was in getting the patient up 24 to 48 hours following surgery, and was tried first on some vaginal celiotomy cases. The purpose as worked out over the past four years was, he said, "for more rapid and complete recovery and to free the patients from many irksome and disabling features of after treatment as usually carried out." Boldt, in 1907, published several papers agreeing in substance with Ries but added to the procedure the wearing of a tight abdominal binder. The method received wide acclaim in Central Europe about 1912. In general, however, it received a poor reception in the United States, and University clinics did little in its development or evaluation. Most of the

surgeons kept their patients in bed three weeks or more, and some even used plaster spicas after herniorrhaphies.

In Europe Rehn (1902) proposed rest and muscular activity as well as a sitting position for the postoperative patient. Henle in 1908 introduced his "Spaziergang im Bett" as a substitute for walking. Newburger (1943) feels that much of the disillusionment of this method in the early 1900's stems from the use of coarse catgut and running sutures, which he believes was an impairment to proper wound healing.

In this country, interest in the subject was stimulated again in 1941 by Leithauser. In 1938, a patient of his disregarded orders and left his bed a few hours after surgery. The patient insisted on leaving the hospital the following day, and on the second postoperative day he was driving his auto. On the third day, the patient was working in his garden, feeling well, and was in excellent condition. Leithauser says that this aroused his interest, since he was unaware that early rising had been applied previously here and abroad.

Campeanu (1940) carried early ambulation to the extreme when he reported 1,300 cases, where many of the patients walked to and from the operating room. He performed one appendectomy on an assistant who immediately performed an operation of his own. Another assistant had an appendectomy and then immediately helped

Campeanu on the next operation. These, of course, were stunts designed by Campeanu to demonstrate what he believed to be the relative innocuousness of "simple" operations, and the ease with which a surgical patient may be ambulated.

INDICATIONS AND CONTRA-INDICATIONS FOR EARLY AMBULATION

Newburger (1943) maintains that the indication for early ambulation is an aseptic operation with firm closure of the incision. He admits however, that some authorities may not be incorrect in feeling that those with draining wounds can also be gotten up early. Laparotomies and herniorrhaphies are types of surgery in which early ambulation is most valuable, according to Newburger, because of their high incidence of postoperative complications. He adds that the suture technique is not a prime consideration. Keyes (1947) reports that, in his opinion, early rising may be practised on patients with any type of abdominal and pelvic surgery including hernias, appendectomies, Cesarean sections, gastrectomies, and cholecystectomies.

Newburger (1943) divides the contra-indications for early ambulation into two types. As general contra-indications are cardiac insufficiency, shock, severe anemia or cachexia, hemorrhage or its fear, presence of thrombi or emboli, or long pre-operative bed confinement. Local contraindications are peritonitis, cholangitis, pancreatitis, liver infections, potentially infected incisions, or insecure gastroenteric anastomoses. On the other hand, Trice (1947) states that infection, peritonitis, fever, and moderate circulatory deficiency are not in themselves contra-indications to early ambulation, but involve greater

scrutiny and judgement by the surgeon. He considers profound shock and prediction of a fatal outcome as the important contra-indications. Technically, Trice would add an un-anatomical incision and poor choice of suture material as unfit for early rising.

A pioneer advocate of early rising, Boldt, (1907) regarded vomiting and a rapid or arrhythmic pulse as the contra-indications. Spang (1946) lists shock, anemia, cardiac insufficiency, hemorrhage, peritonitis, insecure gastro-intestinal anastomoses, and suspected presence of thrombi or emboli. Nixon (1944) writes that drains in situ, elevated temperature, indwelling duodenal tube, marked anemia, hemorrhage, or peritonitis are contra-indications. Nelson (1944) lists the following: 1) Failure to observe prerequisites of optimum healing of the wound; suture material other than cotton or wire; deficiency of vitamins or proteins. 2) Shock, peritonitis, hemorrhage, cardiac failure, pneumonitis, or thyroid crisis. 3) Potential or actual wound contamination, infection, hemorrhage, or dehiscence. 4) Extreme debility. 5) Second stage of thoracolumbar sympathectomy where the patient cannot immediately tolerate an upright position. 6) Lack of adequate and intelligent nursing supervision. Keyes (1947) merely mentions "complications" as a contra-indications to early ambulation. Leithauser and Bergo (1941) list contra-indications as marked abdominal distension, an insecure wound, severe shock, or undue rigidity of the abdomen.

ADVANTAGES OF EARLY AMBULATION

Ries (1899) said that patients who are up within the second postoperative day, "are able to leave the hospital at an earlier date than has been customary and in condition of strength, so that they can follow their occupation within a few days after discharge."

Ries noted that those up early were hungry and ate in contrast to those who lingered in bed without appetite. Hemorrhages and abdominal hernia were not seen in the early risers, said Ries.

Boldt (1907) saw no disadvantages to early ambulation. Advantages, however, included diminished postoperative nausea, less vomiting and distension, early return to bowel action, decreased bronchial and pulmonary complications, fewer circulatory disturbances, better food assimilation, and more rapid recovery with less weakening.

Campeanu (1940) found a decrease in circulatory retardation and incidence of respiratory infection in postoperative patients who were up early. Leithauser and Bergo (1941) reported on 370 appendectomies with an average time in bed of $1\frac{1}{2}$ days, and 49 laparotomy and 9 herniorrhaphy cases who were in bed an average of 1.9 days after operation. He found no untoward effects. Morbidity, number of complications, and the period of disability were materially reduced because of exercise in bed, early rising, and ambulatory activity.

Nelson and Collins (1942) reported on gynecological patients

in which nonabsorbable cotton sutures and early ambulation were used. They were impressed with the rapid convalescence, absence of postoperative weakness, quicker bowel and bladder return, and lessened morbidity. Powers (1944) and Spang (1946) say early ambulation results in better pulmonary, circulatory, gastrointestinal, musculoskeletal, and reparative physiology. The psychologic attitude of the patient to surgery and to the hospital changes for the better. They note too the economic advantages. Nixon (1944) believes that early walking is both safe and desirable. This worker feels it should be combined with wire sutures. Advantages enumerated by Nixon include earlier resumption of normal activity; less atelectasis, pneumonia, and other pulmonary complications; less catheterizations, bedpans, distension, and ileus; better wound healing; economy to the patient; and decreased demand on hospital facilities. Furthermore, the patient enters the hospital with a higher morale if he knows that he can return to normal activity at an early date.

Schafer and Dragstedt (1945) observed the early rising of 103 general surgical patients and their impression was very favorable. They noted improved morale, avoidance of asthenia, more patient self-care, with less nursing care, shorter hospitalization, and earlier rehabilitation. Nelson (1944) saw reduced postoperative complications especially pulmonary and vascular, less nausea, vomiting, and abdominal distension, better bladder and

bowel action,, maintainance of normal muscle tone, faster convalescence, better morale and mental attitude, and economy to both the patients and the hospital. Keyes (1947) says the benefits of early ambulation include elimination of gas pain and postoperative ileus, rapid strength gain, better bowel and kidney function, less embolism, and no greater incidence of postoperative incisional hernia. Allen, Linton, and Donaldson (1947) feel early ambulation has many advantages in approximately $\frac{1}{2}$ the patients treated surgically. They declare that ambulation combined with the use of non-absorbable sutures on wounds made on an anatomic basis, they avoid the complications of convalescence. The patients return to their occupation earlier, normal bodily functions are enhanced, and hospital days are saved. Jackson (1947) says early ambulation reduces the necessity of catheterization, enemas, suction, and intravenous therapy. Peristalsis is induced; gas pains and ileus are reduced; incidence of atelectasis and pneumonia is lessened; and the patient eats sooner.

One might say then that the advantages claimed for early ambulation embrace the physiologic, psychologic, and economic aspects. Physiologic advantages include avoidance of asthenia, absence of hollow viscus atony, better wound healing, reduced incidence of pulmonary atelectasis and pneumonia, fewer gas pains, better elimination, diminished atrophy from disuse of sutured layers, improved circulation in the area of the wound, and a more rapid recovery. Discussion of the question of any decrease in vascular

complications is being deferred. Psychologic results are a lifted morale, simplified after care, and a reduction of chronic invalidism. Economic benefits are a shorter hospital stay and a quicker resumption of occupation.

RESULTS OF EARLY AMBULATION

In order to determine whether the reasoning back of the clinical application of postoperative exercises could be substantiated, Potts and Smith (1941) performed a series of experiments on six dogs. They showed by direct measurements that breathing and leg exercises cause great variations in the volume blood flow in the inferior vena cava. Contraction of the leg muscles increased the volume flow 250%. There was also a distinct increase of volume flow in the vena cava induced by deep breathing. Clinically these authors believe that deep breathing and leg exercises are of value in preventing postoperative thrombosis and pulmonary embolism by assuming that this increased blood flow "washes out" any accumulation of blood elements which might lead to beginning formation of thrombi.

In 1943 Newburger produced standardized laparotomy wounds in rats, and at intervals of 3, 5, and 10 days, the strength of the wound was determined in animals which were kept at rest and in others which were exercised. Exercise rather than immobilization was found to hasten the increase in tensile strength of the experimental abdominal incision.

Baker and Sedwitz (1943) injected diodrast into the leg veins of walking and immobilized patients. The dye spread to the femoral vein of the ambulatory patients in an average of 15

seconds. It remained in the leg 15 minutes and longer in the immobilized patients. This was cited as an example of the importance of muscular activity in maintaining a lively circulation.

D'Ingianni (1945) reports that dogs and rats active soon after surgery show an observable and recordable increase in tensile strength of their wound as compared with animals permitted only progressive, delayed amounts of activity. This same investigator says that experimenters have shown that wound disruption in animals usually occurs from the 5th to the 9th day. Clinicians find the incidence greatest from the 8th to the 14th day following surgery. Why then, asks D'Ingianni should patients be allowed up for the first time within this period. Pulmonary embolism occurs oftenest between the 3rd and the 13th postoperative day, he states. This coincides with the sudden death from this catastrophe when the patient sits up for the first time and the thrombus formed about 7 days before breaks off.

Pneumonitis, continues D'Ingianni, especially hypostatic pneumonia in the aged has long been a bugbear to the surgeon. Gravity produces stasis followed by edema of the tissues, which encourages the growth of organisms. Muscle contraction accelerates blood flow, and even a change from sitting to standing position increases the circulation time in one type of test about 1.5 to 4.5 seconds. Anesthesia, too, remarks D'Ingianni, predisposes to infection of the respiratory tract and phlebitis,

so that avoidance of any additional factor producing stasis is imperative. The aim, it is felt, is to make every effort to avoid the pathophysical phenomena imposed by anesthesia and a reclining position. Standing permits of a greater expansion of the lungs, and early ambulation causes an early return to normal vital capacity.

Schafer and Dragstedt (1945) observed a lower postoperative fever of shorter duration in the early risers, related, they believe, to the observed improvement in respiration.

Blodgett and Beattie (1946) compared 238 consecutive cases of those who walked on the first or second day with 443 consecutive cases who walked after the first postoperative week. Factors of age, sex, anesthesia, and type of incision were considered. They studied pulmonary, vascular, and wound complications. The results show a more rapid gain in strength, less discomfort, less nursing care, and an earlier discharge for the early risers. Vascular complications in the latter group were increased, however, and the authors feel that early rising is not the answer to postoperative venous thrombosis. They presented the chart on the following page:

ANALYSIS OF COMPLICATIONS IN EARLY AND NON-EARLY

RISING PATIENTS

	1st DAY RISING		2nd DAY RISING		NON-EARLY RISING	
	NO.	%	NO.	%	NO.	%
Total Patients	185		53		443	
Complications:						
Pulmonary	9	4.9	4	7.5	35	7.9
Atelectasis	8	4.3	3	5.7	28	6.3
Phlebitis	6	3.2	1	1.8	8	1.8
Infarct	3	1.6	0	0	2	0.4
Fatal	1	0.54	0	0	1	0
Wound Disruption	2	1.0	1	1.8	12	2.8
Wound Infection	5	2.7	0	0	25	5.7
Pneumonia	1	0.54	1	1.8	7	1.6
Died	1	0.54	1	1.8	10	2.3

In 1947 Blodgett and Beattie published some results of early rising in 238 cases of major abdominal surgery at Peter Bent Brigham Hospital as compared with 443 cases who got up after the 7th day.

	Early Risers	Late Risers
Atelectasis	4.6%	6.3%
Deep Leg Thrombophlebitis	2.9%	1.8%
Postoperative wound disruption	1.3%	2.7%

There was no effect on the recurrence rate of hernia.

The same type of study was undertaken by Cornell and Lin (1947). They compared 221 consecutive cases of major surgery from January 1944 to January 1945 where the patients rose late (Group I) with 266 unselected, consecutive cases from January 1945 to March 1946 where the patients were up within the first 24 hours postoperative (Group II). There were 18 complications in Group I; 10 in Group II; 8 pulmonary complications in Group I, 3 in Group II; 5 cardiovascular complications in Group I, 1 in Group II. There was no thrombophlebitis and no dehiscence in either. There was no significant difference in the post-operative temperature rise nor in the time required for remission of fever. No difference in the death rate. In their evaluation, the authors state that the early risers feel better and can resume their jobs earlier. Furthermore, these patients

are not inconvenienced by the use of bedpans or catheters.

In D'Ingianni's series (1945) vomiting occurred on the second day in 4% of the early risers and 32% of the bed resters. Purgatives had to be employed postoperative in 10% of the early risers and 85% of the bed resters.

DISADVANTAGES OF PROLONGED BED REST

Mc Micheal and Mc Gibbon (1934) investigated postural changes in lung volume. They found that in the recumbent position the fully expanded lung is diminished in volume by 340 c.c. This is the result they feel, of pulmonary congestion.

Newburger (1943) made the statement that bed rest, especially in the first few postoperative days, is a breeding place for complications. Dock (1944) says that the evils of bed rest are potentiated by anesthesia, narcotics, or other medication, and by the results of the original illness. Young patients are not as bad off, he notes, since it is more difficult to keep them down in an inactive state. The sequelae of complete bed rest are bone atrophy, muscle wasting, vasomotor instability, constipation, cathartic habituation, and backache. In the elderly, one is likely to see obstructive uropathy, pulmonary edema, and bed sores. A patient flat on his back shows a decrease in blood volume and a smaller caliber of peripheral veins. If he is propped up, the veins of the pelvis and legs dilate, and the blood velocity decreases. It is in this case that clots may be dislodged with a sudden rise of venous pressure.

Spang (1946) says that enforced inactivity in bed promotes postoperative complications like atelectasis, hypostatic

pneumonia, intestinal distension, ileus, passive congestion, and venous thrombosis with embolism and infarction.

Among those studying changed physiology following surgery were Churchill and McNeil (1927). They found a marked decrease in vital capacity due to splinting of the muscles following laparotomy. This amounted to 25 to 50% of the preoperative capacity. They found that vital capacity returns to normal in three days in the ambulatory patient and in 12-14 days in the immobilized patient. Lister (1927) is of the opinion that operation through the anterior abdominal wall produces inhibition of diaphragmatic respiration. For a freer muscular action and well balanced respiration he recommends massage to the lower limbs and breathing exercises at the earliest possible moment postoperative. Powers (1928) finds that a marked reduction in vital capacity occurs after abdominal operation and thyroidectomies. He does not find this decrease after surgery on the extremities and rectum.

Leithauser and Bergo (1941) advanced the theory that pathological reflexes originate from the area of mechanical and chemical injury at surgery which impair respiration and initiate a delay in peripheral circulation. Bed confinement, they find, favors this development. The effects produced are limited excursion of the thoracic cage and a combination of vasospasm and capillary dilatation.

Trice (1947) lists respiratory, gastrointestinal, and circulatory complications as the major changes which follow surgery. Respiratory function is crippled, he maintains, which results in pathological physiology unless offset by deep breathing, coughing, and walking. The trauma of surgery brings about vasoconstriction of some vessels and vasodilatation of others. The result is pooling of stagnant blood in the legs and viscera with a loss of blood volume, poor distribution of nutriment, and impaired removal of waste products from the tissues. This circulatory stagnation, anoxemia, and increased capillary permeability eventually leads to peripheral circulatory collapse. This syndrome is enhanced by inactivity, since activity and muscle tone are prominent factors in maintaining a proper blood supply. The gastro-intestinal complication is a loss of motor function. Though this is beneficial and protective during the early hours of healing, serious consequences may develop if prolonged.

TECHNIQUE OF EARLY AMBULATION

The technique employed in getting the patient up early differs in minor aspects according to the author. Boldt (1907) regularly used a Scultetus plaster binder about the abdomen for his early rising surgical patients. This, he felt, minimized the danger of wound disruption or hernia, and allowed his cases to be out of bed in 24 to 48 hours.

Clairmont (1922) has his patients sit on a chair the day following operation, providing there is no fever and no drain. On the second day, the patients are allowed to walk. Lockhart-Mummery (1922) recommends that as soon as the effects of the anesthetic have worn off, the patient should move or should be encouraged to move about.

Coryllos (1930) advocates breathing of 5 to 10% carbon dioxide and oxygen for 3 to 5 minutes several times daily following surgery. At the same time the patient's position is changed. King (1933) feels that the carbon dioxide may be a help but is not a preventative for pulmonary complications.

Gamble (1935) is one of the advocates of the use of bicycle pedals for muscle exercise. The apparatus is hooked onto the bed, and the patient is encouraged to "pump away". Portis (1936) is also in favor of this device. In addition, his patients sit on the edge of the bed and move their legs,

but they do not walk until the fourth to sixth day.

Leithauser (1943) developed a technique which is much used today. The morning after operation, the patient assumes a right lateral position with his feet over the edge of the bed, and he is assisted to a sitting position. He then stands by the bed and is made to cough. This is followed by the patient taking a few steps, though in more serious cases the actual walking may not take place until the second or third day. If the lungs are moist the coughing is repeated during the day, and it is only occasionally necessary to continue this to the third day. The patient remains as active as he can tolerate. Leithauser's appendectomy cases are usually out of the hospital on the fourth day and come to the office for removal of clips on the fifth or sixth postoperative day.

Nelson (1944) tilts the bed so that the head is elevated immediately after the anesthetic recovery. It is then leveled and the patient sits on the bed side and takes deep breaths and coughs. He then lies down again and the head is again elevated. After a short rest the patient stands and is encouraged to empty his bladder. Ambulation is begun the first or second postoperative day.

The patient's of Nixon (1944) sit in a chair or on the bed on the second day. They are given bathroom privileges on the

third postoperative day, and often leave the hospital on the fourth day. Nelson (1944) lets the patient decide if he wants to get out of bed early. He states that most of his cases are ambulatory within the first 72 hours. Sprang (1946) also lets the patient be the sole judge of his activity.

D'Ingianni tells his patient the day prior to surgery what is expected of him. He is informed that early ambulation is an aid to getting well and helps to prevent pulmonary complications. He is further warned that it may be hard to cooperate the first three days, but if he does, he can walk and possibly go home on the fourth day. The regime followed is to sit on the side of the bed the first postoperative day, sit in a chair the second day, and usually walk on the third day. Some patients complain bitterly, a few even faint. But most discomfort is gone on the second day, and D'Ingianni says that no patient has stated that he regretted early ambulation.

Cornell and Lin (1947) employ a procedure rare for modern surgeons in that their patients have tight abdominal binders. They usually stand within 24 hours following surgery, and are assisted to a chair where they rest for 15 to 30 minutes. This routine is repeated twice on the second day, and by the 5th to 7th day they can walk to the bathroom alone. No catheterization is employed. Regular breathing and postoperative exercises are

carried out in bed, and the patient is encouraged to cough often.

Keyes (1947) tells the patient the day before what is expected of him and lets him think about it. Then on the first day, he sits on the bed, stands, takes some deep breaths, coughs, and takes a few steps. This procedure takes about 10 minutes and is performed twice on the first day. This is gradually increased according to the patient's tolerance. Ochsner (1947) says that it is the worst thing to let the patient get out of bed and just sit. Ambulation means just that, he maintains, and if actual walking is not undertaken, it is far better for the patient to lie in bed in a horizontal position and perform active and passive foot exercises as a prophylaxis against phlebothrombosis.

OBJECTIONS TO EARLY AMBULATION

Critics of early ambulation at first warned that the procedure would mechanically damage the wound, delay healing, cause postoperative herniation or dehiscence, and weaken the heart. Experience has shown that these complications may actually occur less often in the patient who rises early as compared with those who remain in bed over ten days. But even today early ambulation is not employed by many prominent surgeons, and a common explanation is that the patient is too sick to have to get up to walk, and will do best by prolonged rest.

In 1908, Chase declared that imperfect abdominal support and too early mobility are frequent exciting or contributing causes for weak abdominal walls and resulting hernias. Other things being equal, he maintained, healing will be facilitated in proportion as the abdominal muscles are quiescent. "Mechanical support of the abdominal wall and freedom from voluntary mobility of the body are the prime factors which influence such restoration of the parts", said Chase. Some critics even charged that the prime motive of many surgeons for early ambulation was to attract attention by the novelty.

Kelly (1911) saw some advantages to early ambulation, but thought that it was too upsetting for some delicate females to

get up under one week. Miller (1911) said that the post-operative patient is a person with decreased resistance, strength, and vitality. To recuperate he must have absolute bed rest. Gebele (1913) warned that the occurrence of thrombosis and embolism is increased unless moderately long rest and quiet in bed is practised.

But the tide is changing, and an example is that of Graham who commented editorially in the 1943 Year Book of Surgery on the first Leithauser report, by saying something must be wrong with early rising, as it had been tried so often before and didn't seem to stick. But in a personal communication to Trice in 1947, he approved the practise.

DEVELOPMENT OF THROMBOSIS AND EMBOLISM

Richardson writing in 1904 said, "the hazards of surgery will always include pulmonary embolism. It cannot be prevented". Phlebitis was considered to be unavoidable from a theoretical and practical point of view, and to be the origin of pulmonary embolism in only a very few cases. Richardson's clinical impression was that embolism takes place before evidence of phlebitis.

The whole theory of embolism stems from Virchow's studies of 1846 to 1856. He first correctly interpreted pathological specimens of clots in the lung. He proved that solid masses could be carried by the blood through the veins to the lungs, and concluded that most clots discovered in the pulmonary artery had origin from the veins of the pelvis or lower extremities. Most of his cases followed childbirth, trauma, and disease.

Many authors have presented their conception of the factors which lead to the development of venous thrombosis. Wilson (1912) wrote that the greatest factor in postoperative thrombosis is a slowing and stagnation of the blood stream. This is helped, he said, by a quiet recumbent posture which serves to reduce the force and rapidity of the heart's action. Lindsay (1925) remarked that there are more thrombi in veins of stasis like the pelvic and femoral. Sepsis, he calls only a contributing cause

by lowering the patient's vitality. The same author claims that gynecological operations lead the list of those prone to develop an embolism. This complication Lindsay considers a disease of later life since age is the most important factor. Lister (1927) said that the liability to pulmonary embolism depends most on age and to a lesser degree on the type of operation performed. Surgery through the anterior abdominal wall is more likely to be followed by embolism due to inhibition of diaphragmatic respiration. Massage to the lower limbs and breathing exercises at the earliest possible moment postoperative are recommended.

Bancroft (1934) gives trauma, venous stasis, dehydration, and infection as the important factors in producing thrombosis and embolism. Use of exercises is recommended as a prophylactic.

Frykholm (1940) traces the development of venous thrombosis in the following terms. When the patient is in bed some period of time, the veins of the lower extremities are collapsed by the pressure of the leg against the mattress. The result is that endothelial cells lining the venous wall may adhere to one another. The cells may become defective, roughened, or torn loose, or thrombocytes and leucocytes may adhere to them, acting as a nidus for thrombosis. Dock (1944) is of a similar opinion, and declares that the phlebothrombosis resulting from the endothelial changes may extend from the peripheral radicals to deeper

vessels of the pelvis with the attendant dislodgement of fatal emboli.

Smith and Allen (1941) do not believe slowed ~~venous~~ circulation is the sole cause of postoperative thrombosis, but feel it is an important one. They studied the blood flow in the foot to carotid sinus pathway, and found that in 82% of postoperative patients it was slowed, while the arm to carotid sinus circulation time changed little. This they ascribe to phlebitis common to the lower extremities.

Barnes (1942) declares that though the etiology of pulmonary embolism is unknown, there are many known contributing factors. The condition is most prone to develop in an obese individual over the age of 40 following an abdominal operation. The incidence seems to be greater in surgery for malignant lesions, so wasting would appear to be a predisposing factor. Barnes further states that heart disease, especially heart failure and immobilization are important predisposing factors. Normal venous return from the lower extremities depends on the "vis a tergo" of the arterial circulation, which in turn depends on the blood pressure, muscular contractions, the negative intrathoracic pressure of respiration, and the plunger like action of the liver on respiration which squeezes blood from the intra-abdominal venous channels. All this, says Barnes, is disturbed

in abdominal operations, which may lead to phlebothrombosis in the lower extremities and the possibility of embolism. Emboli do not usually arise from areas of thrombophlebitis, since the clot is more firmly anchored.

Hunter, Krygier, Kennedy, and Sneed (1945) say that the most important etiologic factor in phlebothrombosis of the lower extremities is simply confinement to bed for any reason whatsoever for more than a brief period. They feel that the logical approach to the problem of phlebothrombosis and pulmonary embolism is prophylactic. Along that line they recommend early postoperative rising together with flexion and extension exercises of the feet, knees, and thighs. They warn, however, that these measures are not a guarantee against thrombosis and embolism.

de Takats and Fowler (1945) list the following causes of thrombosis: 1) Slowing of circulation - this alone cannot form the clot, but it serves to localize it to a certain segment. Prolonged bed rest is a predisposing factor. 2) Injury to the intima, fractures, sprains, gunshot and stab wounds are particular offenders. 3) Increased coagulability of the blood - there is an increase of fibrinogen and a liberation of thrombokinase from the injured area. For prevention the authors recommend early mobilization, elevation of the feet, and dorsiflexion and plantarflexion of the ankles.

McCartney (1945) ascribes thrombosis to the same factors

which de Takats and Fowler enumerated. Ochsner (1945) says injury to tissue as a result of operation results in increased coagulability of the blood because of absorption into the blood stream of noxious substances derived from the traumatized cells. He uses the Trendelenburg position and active contraction of the muscles of the lower extremity as soon as possible postoperatively. And this investigator makes the statement that the incidence of intra-venous clotting is decreased by early ambulation.

Wilson and Patterson (1947) regard the following factors as favoring intra-venous clotting: trauma, infection, prolonged bed rest, increased platelet count after surgery combined with more sticky platelets, dehydration, and anything favoring slower circulation like Fowlers position or pillows under the knees. For prevention of embolism, they suggest early actual walking to be combined with bed exercises of flexion, extension, and rotation of the ankles and knees six times each hour while awake.

INCIDENCE OF PULMONARY EMBOLISM

de Takats, Beck, and Fenn (1939) say that it is rare that there is manifest thrombosis of the veins of the pelvis or lower extremity before pulmonary embolism occurs. Culp (1940) agrees that in many patients thrombosis is not suspected until the calamity occurs. In fact, in his series of 32 cases only 6 had recognized thrombosis. They occurred from the day of the operation to the 69th postoperative day, though most were evenly divided within the first 28 days.

de Takats and Jesser (1940) collected large statistics and found that pulmonary embolism occurs in 0.1 to 0.2% of all operations, that it accounted for 2% of all deaths, 6% of all postoperative deaths, and is found in 10% of all autopsies. Barker, Nygaard, Walters, and Priestley (1940) studied 1,665 consecutive cases of postoperative vascular complications at the Mayo Clinic. Venous thrombosis, pulmonary embolism, or thrombophlebitis were found in 0.96% of all operations, 2% of all laparotomies, and 3% if on the female pelvis. Of 343 cases of fatal pulmonary embolism only 18 or 5.2% were diagnosed clinically.

Homans (1934) found the incidence of fatal pulmonary embolism high from a thrombosis of the veins in and among the muscles of the lower leg. Hunter, Sneed, Robertson, and Snyder (1941) reported on thrombosis of the deep veins of the

legs on the basis of autopsy findings. They found this condition to be present in 52.7% of all middle aged and older people who had been in bed for varying periods of time. They found a fatal pulmonary embolism in 3.13% of all deaths. In 45.5% of these the most probable source was thrombosed leg veins. There was little difference in incidence between medical and surgical patients or between males and females. The greatest factor in the production of thrombosis is, they feel, sudden bed confinement without exercise. The prophylaxis suggested is planned and supervised voluntary movement with the elimination of too much comfort for the legs.

Allen, Linton, and Donaldson (1945) reveal that at the Massachusetts General Hospital, Castleman found the source of embolus to be the deep veins of the leg in 95% of the cases autopsied. The authors declare that early ambulation has much to commend it, but it does not prevent thrombosis of leg veins in all instances. Ochsner in the discussion of this article maintains that early ambulation does cut down the incidence of postoperative thrombosis.

Barnes (1942) lists the incidence of pulmonary embolism as given by various investigators. The figures at the Mayo Clinic in the years 1917 to 1927 was 6% of all deaths following surgery. In three sets of records from other clinics throughout the country

pulmonary embolism was the cause of deaths in 6.5%, 2.72%,
and 2.07% of all necropsy cases.

EARLY AMBULATION AND THE THROMBOEMBOLIC SYNDROME

The results of early ambulation on decreasing the incidence of pulmonary embolism are still being debated. In any event it may be said that they are not as spectacular as was originally hoped for. Wilson (1912) who encouraged very early free movement on the part of the patient as soon as the nature of the operation and the danger from hemorrhage permitted, said that, "it must be confessed that the reported results from various clinics of getting the patient up early are unconvincing as to the reduction of postoperative embolism."

Shaw and Richards (1938), on the other hand, feel that postoperative exercises have done much to prevent embolism. Gynecology patients at the Manchester Royal Infirmary take routine exercises three times daily consisting of lifting the arms over the head 20 times and raising the legs the same number of times. In a period of 12 years Shaw had 1,635 cases with only one fatal embolism (0.06%). At the same time Shaw had 3,618 patients at St. Mary's Hospital where no exercises were given, and there were 11 emboli (0.304%). They were the same type of patient and received the same pre and postoperative treatment in other respects. So there were 5 times the number of fatal emboli in patients who were not exercised as compared to those who did receive postoperative exercise.

Leithauser (1943) an advocate of early rising, says that Ries, the "father of early ambulation", had only 4 emboli in over 15,000 surgical patients with one of these 4 cases questionable. Erskine and Shires (1945) had 4,596 abdominal operations from 1930 to 1936 where the patients had no postoperative exercise. In the first group there were 19 emboli (0.415%) and in the second 9 emboli (0.203%). Their method consisted of breathing exercises, and bending, stretching, and rolling of the feet during the first to third postoperative day. This is followed by quadriceps contractions, more extensive foot movements, and gentle massage of the legs the next few days. Later the legs are hung over the bed and the trunk is rotated, flexed, and extended.

Zava (1940) reports 6,000 cases of early postoperative ambulation with no incidence of pulmonary embolism. His patients are up the first or second day if possible. If not, the patient is kept in bed until the second week, as he believes that embolism is likeliest to occur between the third and thirteenth days.

Von Jaschke (1937) reports 300 of his patients up late with an incidence of 2% thromboses with 1% fatal emboli. In a comparable group of 387 of his patients who rose early there were 0.5% thromboses and no fatal emboli. He reports that from 1906 to 1912 at the Essinger University Clinic there were 1,504 operative cases

where the patient was up at the end of the second week, and statistics showed 2.63% thromboses and 1.4% fatal emboli in this group. From 1912 to 1918 there were 2,053 similar operations with the patient up on the second to fifth day. Comparable statistics here were 1.75% thromboses and 0.6% fatal emboli.

Welch and Faxon (1941) feel that the prevention of phlebitis is the key to the prevention of pulmonary embolism. To this end they recommend active movements of the legs in bed to avoid stasis of the blood stream, elevation of the foot of the bed, and early walking. They warn that merely standing by the bed instead of actual walking may increase the chance of thrombosis by slowing circulation in the lower limbs.

Robinson (1944) says that the prevention of phlebitis with its attendant risks is best achieved by exercise of the lower legs immediately after taking to bed. He mentions the simulated motions of bicycle pedaling. Just as good is routine extension and flexion of the ankles and knees. To keep the venous circulation normal Robinson employs elevation of the legs in the Trendelenburg position one hour twice daily, non-constricting abdominal dressings, and deep breathing exercises. He also recommends proper fluid balance and ambulation at least by the third post-operative day.

Trice (1947) feels that there is no substitute for the

benefits of early walking in the prevention of the thrombo-embolic syndrome.

It is obvious then that the reports of various investigators do not agree as to the merits of early ambulation as a preventative of postoperative embolism. Powers (1944) declares that early walking does not entirely circumvent the formation of thrombi. However, he maintains that it may obviate the liberation of emboli of sufficient size to precipitate a fatal postoperative catastrophe, since a thrombus of this size usually does not develop in an active venous circulation.

Dock (1944) says that pulmonary embolism is rare in ambulatory patients or even in those who are up in wheel chairs. Yet Allen, Linton and Donaldson (1947) declare that, "It was felt that early ambulation might lower the incidence of thrombosis and embolism. There is considerable evidence against this and little to support it."

SUMMARY

Advantages claimed for early ambulation are:

- Less postoperative nausea and vomiting
- Fewer gas pains
- Less distension
- Early return to bowel and bladder action
- Decreased pulmonary atelectasis and pneumonia
- Better food assimilation
- Decreased period of disability
- Diminished musculoskeletal atrophy
- Earlier resumption of normal activity
- Economy to the patient
- Decreased demand on hospital facilities
- Reduction of chronic invalidism
- Improved patient morale

The efficacy of early ambulation in preventing postoperative pulmonary embolism is still being debated. Many authorities feel that early ambulation has reduced the incidence of pulmonary embolism. Others deny this. No one has shown that early ambulation materially increases the incidence of pulmonary embolism. It would seem as if the surgical patient of today may well benefit from the proven advantages of early ambulation.

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