

TREATMENT OF HEART WOUNDS.*

REPORT OF SUCCESSFUL CARDIORRHAPHY AND TABULATION OF CASES.

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On July 18, 1911, at 7.10 P. M., a young man, twenty-four years old, a native of Sicily, was brought to the New York Hospital in the ambulance about 30 minutes after he had attempted to commit suicide by stabbing himself with a knife over the heart. He was admitted to the service of Dr. A. B. Johnson, to whom I am indebted for the privilege of treating the case.

I was at the hospital when the patient was brought in and saw him immediately. He was a small, thin man in a condition of profound shock. He was lethargic, and no facts concerning the injury could be elicited from him. The pulse was imperceptible in the radial arteries; the heart sounds were audible but distant and muffled. Percussion indicated an increase in the area of cardiac dulness, though we did not delay to map it out accurately. There was a wound about one-half inch in length in the fourth intercostal space close to the upper border of the fifth rib and just mesial to the nipple. A probe inserted a short distance showed that the direction of the wound was somewhat upward and inward. There was very little external hemorrhage. It seemed reasonably certain that there was a wound of the heart and that death was imminent unless immediate operation could be successfully performed. As the operating room had been prepared for another operation, it was possible to put the patient on the table without delay and to begin the operation less than an hour after the accident.

The wound was protected with gauze and the surrounding skin thoroughly cleansed, after which the wound and the operative field were painted with 3.5 per cent. tincture of iodine. As the patient seemed to experience some pain when the iodine came in contact with the wound, light ether anæsthesia was begun at

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once. The wound was extended along the upper border of the fifth rib toward the sternum, crossing and dividing the cartilage near its insertion. The stab wound entered the pleura, and in exposing the pericardium the pleura was injured further. The pericardium was incised in the direction of the wound, allowing the escape of considerable blood, and the index-finger was inserted into the pericardial sac. It failed to locate the wound in the heart, but palpation of the inner surface of the pericardium revealed an opening in it, corresponding in position to the original surface wound. The exposure of the heart was rapidly improved by making a "trap door." For this the incision was carried upward along the sternum and thence outward along the lower margin of the third costal cartilage. The cartilages of the third and fourth ribs were divided close to the sternum, the third being readily exposed by retracting the soft parts upward. The two cartilages were then carefully lifted, separated from the pleura, and fractured at the costochondral junction, forming a flap with skin and muscles attached; resection of the fifth cartilage was contemplated but was delayed and did not prove necessary. The internal mammary was clamped and ligated above and below when exposed. The opening in the pericardium was enlarged by an incision upward near the sternum, making a triangular flap. Hemorrhage was very free; the operative field was a lake of blood in which were churned bubbles of air.

Palpation revealed the rent in the heart, which admitted the tip of the index-finger. As the finger was withdrawn from the hole a well-vaselined silk suture was passed from above downward on a fine curved intestinal needle; this was tied and left long. By gentle traction on this suture the heart was readily lifted and rotated, so that the wound was rendered visible and readily accessible. The wound involved the left margin of the heart somewhat posteriorly; it was about one-half inch in length, transverse on the long axis of the heart, and approximately one and one-half inches above the apex. Though the wound was partially closed by the first suture, blood gushed out whenever the finger was momentarily lifted to pass a stitch. Five stitches were inserted and tied before the bleeding was completely controlled. All visible blood was then removed and the pericardium closed with interrupted catgut stitches. There was considerable tension between the edges of the pericardial wound, which caused

some gaping between the stitches in the lower mesial part. The flap was replaced and chromic stitches used to repair muscles and fascia. The skin was closed with silk. In the outer angles of the wound rubber tissue drains were inserted through the skin. At the lower mesial angle of the wound a rubber tissue drain was inserted down to but not into the pericardium. After the wound in the heart had been closed an infusion of 16 ounces of salt solution was slowly given. The operation took about thirty minutes.

Post-operative Course.—For 24 hours after the operation the patient was restless, irritable, and thirsty. He was given morphine freely and saline continuously by rectum (Murphy drip). During this time the highest pulse-rate was 128; respirations were 24–28; temperature 102°. When the dressing was changed at the end of 16 hours and the drains removed, a very large quantity of clear serum exuded from the drainage openings. A rubber tissue drain was therefore reinserted at the lower inner angle. A similar discharge occurred again at the next dressing 30 hours after the operation. At that time the pulse had risen to 132; the temperature remained 102°. White blood-cells were 19,000, polymorphonuclears 83 per cent. The serous discharge continued to be free until 48 hours after the operation, when the single remaining drain was removed from the lower and inner angle of the wound. At this time the pulse was 112, temperature 101°, respirations 24. The patient was refractory and refused to eat, because, he said, he wanted to die; he was also very irritable and restless. Twice he sat up in bed. Morphine was given and he became quiet. Rectal alimentation was begun.

July 22 (fourth day): condition good, pulse 104–124, temperature 102°. White blood-cells 17,500, polymorphonuclears 84 per cent. Patient still refused nourishment. Wound dry and clean.

July 23: condition about the same.

July 24 (sixth day): large amount of serum exuded from the wound, after which the pulse became very rapid.

July 25 (seventh day): constant free discharge of clear serous fluid requiring frequent dressings. The patient still refused nourishment, was extremely weak, and appeared to be in serious condition.

Blood-pressure taken twice a day from the third to the eighth days was always between 90 and 110.

July 26 (eighth day): the patient was persuaded to eat by threats of passing the stomach tube; nutrient enemata were discontinued. Wound dry and clean, temperature normal, pulse 90, white blood-cells 10,000, polymorphonuclears 74 per cent. From this time the convalescence was uneventful. The patient was allowed up on the eighteenth day and discharged from the hospital on the twenty-fifth day.

The man was seen on December 12, four and a half months after the operation. His general condition was excellent. The heart-beats were visible in the fourth interspace three and a half inches to the left of the mid-line; there was a very slight systolic thrill at the apex. Prominences at the sternal attachments of the third and fourth cartilages, where these had been cut, were visible and palpable, also slight depressions where they had been fractured at the pedicle of the flap. Otherwise, examination of the chest revealed nothing abnormal.

The rationality of immediate surgical treatment for wounds of the heart has been thoroughly established by fifteen years of relatively good and constantly improving results. Even in suspected wounds of the heart, when the diagnosis is probable but not positive, exploratory operation is an approved procedure, as has been emphasized by E. Hesse, Foederl, and others, for the following reasons: First, there is no typical clinical picture whereby a wounded heart can always be diagnosed, especially in the first few hours after injury. The classical syndrome, "heart tamponade," due to intrapericardial pressure, is more often absent than present (Borchardt); physical signs in the cardiac region, such as abnormal sounds and increased dulness, are frequently inconclusive; the position and direction of the surface wound are not always convincing; while the suggestive symptoms of internal hemorrhage, hæmothorax or hæmopneumothorax may originate entirely in thoracic lesions other than a heart injury. Thus, in the 21 cases which were the basis of E. Hesse's report, heart tamponade was absent in 13; in only 11 of the 21 cases was

FIG. 1.



Photograph taken on the eighteenth day after operation (author's case).

the diagnosis certain, whereas in 4 it was probable and in 6 doubtful on account of the absence of all reliable signs. Second, it has been shown by statistics that the prognosis, by reason of hemorrhage and shock, becomes progressively worse as the interval between the trauma and the operation lengthens. Therefore, although delay in some cases will render the diagnosis certain, postponement of operation until dangerous symptoms make their appearance is not to be recommended. Third, the immediate results of non-operative treatment are very poor as compared with those obtained by operation (E. Hesse). Moreover, although some heart wounds heal without surgical intervention, there is always danger of secondary hemorrhage from an unsutured wound, and the spontaneously healed heart wound, even a non-perforating wound, leaves a weak scar which may rupture or become the site of an aneurism (Rehn). Loison, as early as 1899, collected nine such cases.

The technic of operation for wounds of the heart may be dismissed briefly, since a number of recent articles enter exhaustively into discussion of the details. There are only a few features on which it is necessary to dwell. These are the use of differential pressure, the method of exposing the heart, and the question of pericardial and pleural drainage.

Technic of Operation.—Careful preparation of the operative field is essential, since many cases which have survived shock and hemorrhage have died later as a result of infection. Experience indicates that anæsthesia should consist in the sparing administration of a general anæsthetic, preferably ether, when the patient shows signs of sensibility. The indications for differential pressure are so striking as to induce its employment. Since the recent development of the Meltzer method, it has become possible for every hospital to be provided with facilities for the use of differential pressure, even if elaborate apparatus, such as those of Janeway and Elsberg, are not available. Therefore, the applicability of differential pressure in operations for wounds of the heart will doubtless

be thoroughly tested in the immediate future, consequently, this detail deserves careful consideration.

A majority of the cases of heart wounds are complicated by opening of the pleura (Borchardt); Sauerbruch puts the figure at 80 per cent. Even if not opened by the original wound, experience shows that the pleura is usually torn during the course of the operation. Pneumothorax with collapse of the lung is therefore likely to occur in every case. But the immediate dangers due to pneumothorax can be eliminated and the late dangers minimized by the use of differential pressure. Therefore, differential pressure permits a disregard of the pleura, and, consequently, expedites the operation by allowing a free transpleural exposure; moreover, it greatly diminishes the tendency to post-operative infection, by allowing dilatation of the lung and consequent absence of pneumothorax following the operation (Sauerbruch). Other less important advantages of differential pressure are that it increases oxygenation of the blood, improves the heart action, renders the technic of the heart suture easier in that it lifts the heart and renders it more accessible, at the same time removing the annoying respiratory movements, and, finally, assists in the discovery of a wound of the lung so that it may be sutured (Sauerbruch and Haecker).

There are some considerations which indicate great care in the amount of pressure used during the first stages of the operation. Sauerbruch and Haecker found in animal experiments that at first a pneumothorax leads to a diminution of heart activity and lessens the bleeding from the heart. On the basis of these findings Matas discourages the use of differential pressure until the heart has been sutured, because he considers that a collapsed lung may be an advantage by diminishing the bleeding from the heart wound. But Sauerbruch and Haecker state that in their experiments continuation of the collapsed lung led to such depression of the heart as to render it necessary to dilate the lung in order to save the animal, and Sauerbruch believes that low pressure, such as 3

mm.Hg, does not increase the bleeding. Therefore, although Matas's warning should be borne in mind, it seems probable that differential pressure, in view of its marked indications, may be used throughout with advantage, danger from increased hemorrhage being averted by a rapid exposure and rapid control of hemorrhage, pressure being reduced to a minimum until bleeding has been controlled. Possibly insufflation of oxygen will prove an advantage in this connection, since it can be used under much lower pressure than is necessary to give the same effects with air (Volhard, Tiegel). In operations for heart wounds, differential pressure has been employed in one case by Friedrich and in four cases reported by Ranzi. As a result of his experiences, Ranzi expresses himself very positively in favor of its use.

The question of exposure of the heart is greatly simplified if it is recognized that an extrapleural cardiorrhaphy is rarely possible, and if dependence is placed upon differential pressure for controlling the dangers of pneumothorax. The numerous methods which have been suggested for exposing the heart will not be enumerated here. The principles of exposure by which almost all indications can be met most satisfactorily are the intercostal incision, the osteoplastic flap, and the extrapleural exploratory pericardiotomy.

The intercostal incision, as Wilms states, affords free exposure of the heart, can be applied much more quickly than a flap operation, and causes less hemorrhage, while the resulting pneumothorax cannot be urged against the method since it is rarely possible to avoid its occurrence by other procedures. It should be elected when differential pressure is used, when pneumothorax is already present, or when the condition of the patient makes speed of primary importance. A long intercostal incision placed in the fourth space gives the best exposure, although other spaces may be used. The proper application of this incision necessitates opening the pleura freely; forcible retraction then gives considerable exposure. As in all methods, the internal mammary must be ligated

above and below when exposed. After opening the pericardium in the line of incision, if more space is desired, it may be obtained by cutting away part of the sternum and by section near the sternum of adjacent rib cartilages with or without incision of the soft parts upward or downward.

Although the preservation of the pleura, as Rehn points out, is a distinct advantage, it should be aimed at only in selected cases, since the effort delays the operation and usually fails. The circumstances which warrant an effort toward an extrapleural operation are: differential pressure not available, pneumothorax not present, no wound of the pleura such as would render the effort useless, adequate assistance, and relatively good condition of the patient, for when the condition is grave it is important to adopt the simplest and quickest method and to lose no time in attempts at elaborate extrapleural procedures.

Certain flap methods afford good exposure and offer the best prospects of preserving the pleura intact, when such an effort appears indicated. A flap with lateral base has proved the most satisfactory both in operations and experimentally on the cadaver. A flap, as planned by Kocher, gives admirable exposure. An incision of about 10 cm. is made from the middle of the sternum along the sixth left costal cartilage, which is carefully resected after separating the perichondrium; the pleura is exposed and stripped outward; an extrapleural exploratory pericardiotomy is then possible. From the inner end of this incision, a vertical incision is carried upward on the sternum as far as is indicated, even to the third rib; a third incision of 8 cm. is carried horizontally outward. A flap of the fifth, fourth, and, if necessary, third cartilages is lifted, separating and stripping the pleura outward. The cartilages are broken at the costochondral junction. In the event of a small wound being made in the pleura, an effort should be made to limit the entrance of air into the cavity by protecting the hole with gauze; a large wound must be disregarded. This method not only gives a good exposure, but

permits satisfactory primary or secondary drainage in a dependent part of the pericardium and the part uncovered by pleura. Yet for some cases it would carry the exposure unnecessarily low. Therefore, in high wounds a simpler and more suitable procedure may be used by omitting the resection of the sixth cartilage and forming a flap appropriately placed with pedicle outward of two or three rib cartilages, especially the fourth, fifth, and third. Additional space in the direction needed may be obtained by cutting away part of the sternum and section or resection of adjacent cartilages. The pleura should be carefully separated and stripped outward.

In certain doubtful cases the primary incision may be designed for exploration. The original wound, if situated in the precordial region, may then be extended and deepened layer by layer, the edges of the original wound being excised (Peck). If it appears indicated, the incision may be utilized for carrying out one of the methods of exposure already mentioned or for an appropriate atypical exposure. If the wound is not in the precordial region, in the absence of differential pressure, an extrapleural exploratory pericardiotomy may be used advantageously. For this, resection of the sixth cartilage, as in the first step of Kocher's procedure, is to be recommended. In the rare condition of a wound of the right side with right pneumothorax, the exposure of the heart must be planned to avoid opening the left pleura, especially when differential pressure is not used. Partial resection of the sternum is then indicated. König suggests as the best procedure that of Marion with the modifications of Wehr and Lorenz.

After exposure of the heart, if any difficulty is encountered in locating the wound, the index and middle fingers of the left hand may be inserted posterior to the heart, the thumb being placed on its anterior surface, and it may then be lifted, turned, or drawn downward for inspection (Rehn, quoted by Sauerbruch). But if hemorrhage is excessive, the method suggested by Sauerbruch and Haecker may be advantageously

used: the left hand is inserted so that the right auricle with its entering vessels lies between the third and fourth fingers, while the thumb and index-finger grasp the lower portion of the heart and luxate it upward; this, they say, serves to bend the vessels and control bleeding, while at the same time the heart wound is rendered accessible. Rehn suggests controlling hemorrhage by compressing the inferior and even the superior vena cava with the fingers of the left hand.

For suturing the heart, both chromicized catgut and silk have been used. Yet the interrupted silk suture well vaselined has much to commend it, in that it offers a finer material, which causes the minimum of trauma, is well tolerated, allows the knots to be tied more securely, and is not loosened by subsequent softening of the suture material at the knots. In a case of wound of the left ventricle reported by Schoenborn catgut sutures were used and were found at autopsy a few hours later so loose that they probably would have given way.

After the controlling stitch has been placed, it should not be difficult in most cases to insert the remaining stitches. In our case this was done quite easily by having the assistant draw on the first stitch with one hand and control the bleeding by pressure with a finger of the other hand; for each subsequent stitch this finger was momentarily lifted. It was found impossible to differentiate between systole and diastole in tying the sutures, and case reports show this to be a common experience. The suture should not penetrate the heart wall, yet reports indicate that in thin-walled portions of the heart it is impossible to determine accurately the depth of a suture. Occasionally, as in cases reported by Neumann and E. Hesse, cardiorrhaphy is unsuccessful on account of friability of the heart muscle and persistent cutting through of the sutures. In such an event the latter recommends cardopericardoplasty.

For cessation of the heart action during operation, gentle massage is indicated. Injections of salt solution into the cavity of the left ventricle (Gütig) and camphor (F. Hesse) or adrenalin (Leichner) into the wall of the ventricle have been tried but without very encouraging results.

After the heart has been repaired, a saline infusion should be begun and the lung should be inspected when an injury seems probable, because a neglected pulmonary injury may lead to a fatal outcome. Death in one of Heinrichsen's cases was due to a simultaneous injury of the lung which had been overlooked. The importance of this step is further emphasized by statistics, which indicate that the lung is injured in a large proportion of cases, 13 per cent. of stab wounds according to Loison.

The closure of the pericardial sac should be made with interrupted catgut sutures, because tension between the edges of the wound may occur not only at the time of operation but later as the result of distention of the sac with serum, consequently distribution of the strain among a number of stitches renders the suture more secure.

The question of drainage is important, since a large proportion of cases are lost as a result of the infection of the pericardial or pleural cavities. It is fair to assume that faulty judgment in the matter of drainage is often responsible.

There are strong arguments for and against pericardial drainage which may be briefly considered: it is probable that a considerable post-operative exudation of serum, due to traumatic pericarditis, is not infrequent after operations on the heart, as is evidenced by the cases of Magenau and Torre, which were not drained, and the case here reported, in which no drain entered the pericardial sac. Should this serum be confined within the pericardial sac, the heart action may be impaired, as in the cases of Proust and Magenau, in which the heart action improved after liberating the fluid; should it accumulate in the soft parts outside of the pericardial sac, it would favor extensive suppuration. Hence an exit for this fluid would prove an advantage. If infection has been introduced by the original wound or during the operation, drainage will obviously be an advantage. If care be taken in the dressings, subsequent infection should not occur, since the discharge, although free, persists as a rule for only a few days. While dangerous accumulation of serum may be removed by

aspiration, the procedure is not without danger, and the indications are not clear until serious symptoms have developed.

On the other hand, the irritation of a drain projecting into the sac might reasonably be supposed to favor excessive exudation, as occurred in the cases of Schoenmaker, Proust, Neugebauer and Renner, and the formation of adhesions, which militate against the best functional activity. That serious results may be due to adhesions is shown by Walther's case of stab wound of the right ventricle which was sutured. Three years and eight months after operation death occurred as the result of cardiac insufficiency. At autopsy extensive cardiopericardial adhesions were found; the cicatrix appeared as a wide translucent area, and at this site the heart wall was very thin, though there was no aneurism.

It is evident that drainage in each case must be decided by the individual indications. In some cases in which there is short exposure and little trauma, closure without drainage should be carried out; on the other hand, when the nature of the wound and the operation render infection probable, the drain should penetrate slightly into the sac. But in doubtful cases, on the basis of the above reasoning, it appears safest to treat the detail of pericardial drainage as follows: First, to leave unsutured a small portion of the lowermost, or in an intercostal incision the innermost, part of the pericardial wound, so that in the event of a large accumulation of serum the fluid may exude through the opening, and, second, to provide a surface exit for the serum by inserting a drain down to but not into the pericardial sac. This method proved fairly satisfactory in our own case, although the drain was too small and not sufficiently loose to allow continuous drainage. A cigarette or rubber tissue drain should prove most satisfactory. As suggested by case reports, any form of drain, such as gauze, which is likely to obstruct and not drain should be avoided. On the other hand, a rubber tube while best for drainage might communicate with the pleural cavity when this has been opened, especially in an intercostal incision, and cause a pneumothorax.

Drainage of the pleural cavity has been urged, notably by F. Hesse, on the theory that infection in the pleural cavity that has been opened is peculiarly prone to occur, not only as the result of the wound or ordinary operative infection, but as the result of air infection, since air is sucked in and expelled with every respiratory movement. Moreover, the pleural resistance is diminished by prolonged exposure to the air, operative traumatism, post-operative pneumothorax, and the persistence of blood or the accumulation of exudate in the cavity. Further, the pleura does not react to the same degree as the peritoneum, in localizing inflammatory processes through adhesions.

Against drainage may be urged the resulting pneumothorax, which can be entirely eliminated by differential pressure when drainage is not used; and the danger of infection from without, as the result of the drainage. Infection in a drained case is difficult to prevent because the discharge in such cases is usually copious and prolonged (cf. cases of F. Hesse, 1909, Einar Key, and others).

Statistical analyses of the reported cases do not aid as much as might be expected in deciding the question of drainage, since conclusions based on the statistics are not convincing by reason of the numerous modifying factors of each case, such as associated pericardial and lung lesions. Further, accurate statistics are impossible, because many unsuccessful cardiorrhaphies remain unpublished; moreover, complete details of published cases are often not given. Yet, recent writers have been somewhat influenced by statistical studies. Thus E. Hesse favors closure of pleura and pericardium on the basis of his own experiences and the following statistical considerations:

Pericardium and pleura were closed in 30 cases, 21 (70 per cent.) recovered.

Pericardium and pleura drained in 43 cases, 25 (58 per cent.) recovered.

Pericardium closed, pleura drained in 25 cases, 10 (40 per cent.) recovered.

Pericardium closed, no statement as to pleura, in 15 cases, 10 recovered.

Pericardium drained, no statement as to pleura, in 8 cases, 4 recovered.

Hesse's personal cases in which the patient survived operation: both closed 6 cases, 5 cures; both drained 6 cases, 1 cure; pericardium closed, pleura drained 3 cases, 0 cures.

On the other hand, although the statistical compilation of Rehn (1907) does not show the advantage of closure of the pleura, Rehn proclaimed himself against pleural drainage.

It is my opinion that the pleural cavity should not be drained as a "prophylactic" step against possible infection unless there are very strong reasons for suspecting infection. In general, the accumulated blood should be removed entirely from the pleural cavity by aspiration and gentle sponging, avoiding, as far as possible, injury to the pleura. The pleural wounds should be carefully closed with distention of the lung if differential pressure is used. Evidences of pleural infection should be watched for, and, if necessary, drainage be established later, as has been done in a number of cases. In exceptional cases where exposure has been prolonged and when from the nature of the wound and its administration infection appears probable, the thorax should be drained, especially if differential pressure has not been used. The drainage should be made posteriorly just as in empyema; as emphasized by F. Hesse, anterior drainage can be of little use.

The number of reported cases of heart suture has increased rapidly in the last few years. E. Hesse (Russia) reports twenty-one cases which were treated by cardiorrhaphy in the Obuchow Hospital in St. Petersburg, four more being added during the preparation of the paper. F. Hesse (Germany) contributes three more cases operated upon by him. He and others likewise report quite a number of old cases not previously published.

E. Hesse (1911) was able to collect 219 cases with 116 deaths and 103 recoveries. He points out that this ratio

gives a false impression of the percentage of cures, because numerous failures are doubtless not reported. He calls attention to the relatively small number of cases in the United States and England and the large number in Italy and Russia.

An effort has been made, with the co-operation of Dr. F. Robbins, to tabulate 77 cases of heart suture reported in 1909, 1910 and 1911, including earlier cases not previously reported, in order to supplement the table of 159 cases published by Peck in 1909, bringing the total to 236.

CONCLUSIONS.

1. The treatment of heart wounds should be surgical. Even in suspected wounds of the heart, when the diagnosis is probable but not positive, exploration should be performed.

2. Careful preparation of the field of operation is essential, since many fatal results have been due to sepsis.

3. Light general anæsthesia, preferably ether, should be given when there are signs of sensibility.

4. It is important to recognize that in a large proportion of heart wounds the pleura is opened and that an extrapleural cardiorrhaphy is rarely possible.

5. Differential pressure offers marked advantages chiefly by eliminating the immediate and minimizing the late dangers due to pneumothorax. Its use expedites the operation by allowing a free transpleural exposure. But prior to the control of bleeding from the heart wound positive pressure should be used with great care because it may increase hemorrhage.

6. (a) A transpleural exposure with long intercostal incision is ordinarily the best because it affords free exposure of the heart, can be applied much more quickly than other procedures, and causes less hemorrhage. This exposure should be employed when differential pressure is used, when speed is important, or when pneumothorax is present.

(b) An effort to do an extrapleural operation is warranted in exceptional cases. The indications are: differential pressure not available, pneumothorax not present, no injury

to the pleura such as would render the effort useless, adequate assistance, and relatively good condition of the patient. Under these conditions, a flap with pedicle outward is favorable.

(c) In some cases in which the diagnosis is in doubt, extrapleural exploratory pericardiectomy may be performed by resection of the sixth costal cartilage as in the primary incision of Kocher's flap operation.

(d) Atypical procedures are at times indicated.

7. Fine vaselined silk on a curved intestinal needle is the best material for heart suture.

8. The pericardium should be closed with interrupted cat-gut sutures.

9. Pericardial drainage may be dispensed with in some cases when there is short exposure and little trauma. A drain should enter the pericardium to a slight extent when the nature of the wound renders infection probable. But in doubtful cases it is best to insert a drain down to but not into the pericardial wound, a small part of which should be left unsutured. In this way an exit is provided for the large accumulation of serum which is likely to occur as the result of traumatic pericarditis, and no irritation of the pericardium is caused by the presence of a drain.

10. Pleural drainage is a prophylactic step which is often unnecessary and likely to be harmful. Unless there is a strong probability of infection, it is better to delay drainage until infection has occurred and then to do secondary thoracotomy.

TABULATION OF CASES OF HEART SUTURE SUPPLEMENTING PECK'S TABLE, 1909.

Borzymowski, 2 cases (*Centralblatt. f. Chirurgie*, No. 30, 1910, p. 1007): Method recommended and presumably used: skin incision down middle of sternum from third cartilage and outward along fifth. Resection of 3 cm. of third, fourth, fifth cartilages and adjacent half of sternum. Pleura is separated unopened. Heart wound sutured and stitched around with pericardium. Drainage of pericardium. One recovered, one died. Original report not accessible. (*Przeegl. Chir. i ginek.*, Warsaw, 1909, i, p. 50.) These are Borzymowski's fourth and fifth cases.

Boljarski (*Russki Vratsch*, No. 5, 1911; *Centralblatt. f. Chir.*, No. 22, 1911, p. 787): Stab wound, 2 cm. long, between fifth and sixth left ribs, external to nipple line. Male, age 27 years. Hæmopericardium. Wound of left ventricle 5 cm. from apex. Enlargement of skin wound along ribs to 10 cm. Resection of fourth and fifth costal cartilages. Heart wound closed with three silk sutures. Pericardium and pleura entirely closed. No drainage. Left-sided pneumonia. Pericardial friction for two weeks. Recovery. (Case is No. 26 of the cardiorrhaphies in the Obuchow Hospital, St. Petersburg.)

Brewster and Robinson (*ANNALS OF SURGERY*, March, 1911, p. 324): Gunshot wound over fifth left rib mesial to nipple line. Male, age 28 years. Time between injury and operation, 6 hours. Round hole in anterior wall of left ventricle. Quadrilateral incision, division of cartilages of third, fourth, and fifth ribs, with double intercostal incision. Three catgut sutures, covered by continuous catgut. Death on table. Heart massage was ineffectual.

Brod (1904), quoted by F. Hesse: Stab wound in fifth left intercostal space just outside nipple line, 2 cm. long. Male, age 41 years. Pleura penetrated. Hæmopericardium. Time between injury and operation, 2 hours. Right ventricle, transverse wound 1 cm. Skin muscle flap, partial resection of fourth, fifth, and sixth ribs. Silk suture was applied through apex for better fixation. Silk suture of heart wound. Death on table; failure of massage.

Bufalini (1906) (*La Riforma Medica*, No. 49, 1906, p. 1357): Stab wound in mid-line; sternum pierced. Male, age 27 years. Marked hæmopericardium. Time between injury and operation, ½ hour. Very large hole in right ventricle. Extensive flap and resection of sternum. Ten silk sutures. Small gauze drain penetrating lowermost part of pericardium; removed on third day. Pleura not drained. Course, uneventful. Recovery.

Bufalini (1908) (*La Clinica Chirurgica*, xvii, No. 3, 1909, p. 694): Stab wound in fourth left intercostal space. Male, age 27 years. Hæmopericardium. Time between injury and operation, 3 hours. Wound of right ventricle in middle of anterior surface, 1.5 cm. in length. Enlargement of wound to about 11 cm.; section of third and fourth cartilages and resection of part of sternum. Six silk sutures. Pericardium drained with iodoform gauze. Pleura not drained. Pleuritic exudate; patient up in 20 days after operation. Recovery.

Bufalini (1909) (*ibid.*): Stab wound third right interspace 1 cm. outside parasternal line, 3.5 cm. long. Male, age 21 years. Hæmopericardium. Time between injury and operation, 1½ hours. Wound 1 cm. long, in right auricle. Enlargement of stab wound about 10 cm., exposing right margin of sternum. Section of third and fourth cartilages; partial resection of right half of sternum. Two silk sutures. Pericardium drained with iodoform gauze. Pleura not drained. Severe bronchitis. Wound healed by first intention. Recovery.

Ehrlich, cf. Ranzi.

Erdmann (*Med. Record*, vol. lxxviii, 1910, p. 1095): Stab wound,

$\frac{3}{4}$ inch long, of right chest, penetrating fifth costal cartilage. Male, age 21 years. Hæmopericardium. Time between injury and operation, 4 hours. Right ventricle. Exploratory median epigastric laparotomy; extended upward and seventh, sixth, fifth, and fourth costal cartilages divided; sternum cut across at level of fourth cartilage; 8-10 catgut sutures. Cigarette drain into pericardial cavity. Lobar pneumonia and pneumothorax. Up on fourteenth day. Recovery.

Ewald (*Wiener klin. Woch.*, No. 52, 1909, p. 1817): Two stab wounds in cardiac region, between fourth and fifth ribs. Male, age 23 years. Hæmopericardium. Stab wound in third intercostal space, penetrating pleura. Time between injury and operation, 15 minutes. Small perforation, size of lentil, in left margin of left ventricle. Incision along fourth intercostal space, from middle of sternum, about 12 cm. long. Division of fifth costal cartilage close to sternum. Resection of part of fourth rib. One silk suture of heart wound. Closure of pericardial incision with silk sutures. Pericardium drained with strip of iodoform gauze. No pleural drainage. The complicating pleural wound was not sutured. Slight serous discharge for six weeks. Mild bronchitis and pleurisy. Patient up on fifteenth day. Recovery. "Drainage should be limited to the minimum."

Ferretti (2 cases) (*Atti della Soc. Lancis degli Ospedali di Roma.; Jahresbr. f. Chir.*, xii, 1906, p. 705): Penetrating wounds of thorax. Adult males. First case, right ventricle. Second case, left ventricle, near apex. Fontan's procedure, with modifications (osteoplastic flap with pedicle outward). Pleura not opened in second case. First case, death from acute anæmia. Second case, death, forty-ninth day, from secondary hemorrhage, after recovery from purulent pericarditis.

Flörcken (*Münch. med. Woch.*, No. 32, 1909, p. 1634): Stab wound near sternum in fourth left intercostal space, 3 cm. long. Male, age 22 years. Hæmopericardium marked. Time between injury and operation, $\frac{1}{2}$ hour. Right ventricle 2 cm. long. Flap with lateral base; resection of three ribs. Three catgut sutures. No drainage. Mild serous pericarditis. Patient up on sixteenth day. Recovery. Rubber drain was first inserted into pericardium, but was removed when seen to pulsate synchronously with the heart beats.

Foramitti (*Wiener klin. Woch.*, No. 25, 1910, p. 957): Stab wound to right of sternum. Branch of coronary artery wounded. Heart suture. Recovery. "The case is to be reported in detail."

Foederl (1909) (*Wiener klin. Woch.*, vol. xxiii, No. 25, 1910, p. 923): Gunshot wound. Male, age 19 years. Hæmopericardium. Hæmopneumothorax. No tamponade. Time between injury and operation, 2 hours. Left ventricle, 4 cm. above apex. Flap with left-sided base. Suture of heart. Pericardium and pleura washed with salt solution and sutured. No drainage. Uneventful course. Recovery. According to post-operative X-ray, bullet lay near apex.

Foederl (1903) (*ibid.*): Two stab wounds, one above, the other below the fourth rib. Male, age 25 years. Symptoms of progressive hæmopericardium. Pleura intact. Left ventricle, 1 cm. Flap of third and fourth cartilages, without injury to the pleura. Two sutures. Drain-

age of pericardium with gauze. Protracted course; thoracotomy. Recovery. Patient well at time of report, seven years after operation.

Foederl (1907) (*ibid.*): Gunshot wound in nipple line, fifth intercostal space. Male, age 22 years. Complicating injury, gunshot wound in right temporal region. Time between injury and operation, several hours. Wound 5 mm. in diameter anterior wall of left ventricle, 3 cm. from apex. Exit wound posterior wall. Flap 4 fingers' width. Suture of heart wounds. Death after half an hour. Failure of heart massage, salt infusion, artificial respiration.

Friedrich (*Münch. med. Woch.*, No. 4, 1909, p. 210): Stab wound in fifth intercostal space. Adult male. Pneumothorax. Right ventricle. Under differential pressure (Brauer). Flap of soft parts with base at sternum; resection of 10 cm. of fifth rib. Three silk sutures. No drainage. Uncomplicated. Recovery.

Fuchsig (*Centralblatt f. Chir. Beilage*, No. 29, 1911, p. 67): Stab wound of thorax. Perforation of diaphragm. Right ventricle. Suture of heart proved possible through the slit in the diaphragm. Recovery.

Grisogono (*Wiener klin. Woch.*, No. 25, 1910, p. 924): Stab wound in third intercostal space, 3 fingers' breadth from mammary line, 1.5 cm. in length. Male, age 18 years. Pneumothorax; hæmopericardium without signs. Time between injury and operation, $\frac{3}{4}$ hour. Wound 1.5 cm. long, left auricle. Triangular skin-muscle flap. Resection of third and fourth cartilages for 7 cm. from sternum and 5 cm. of second. Four silk sutures. Pleural cavity drained with gauze through lower angle of wound. Pericardium, no drainage. Pneumothorax. Slow recovery; discharged well two and a half months after operation. A year later practically normal.

Guetig (*Wiener med. Woch.*, No. 43, 1910, p. 2543): Stab wound, 3 cm. long, two fingers' width outside of and below left nipple. Male, age 40 years. Time between injury and operation, $\frac{1}{2}$ hour. Right ventricle, oblique wound, 3 cm. Skin-muscle flap with lateral base, division of fourth and fifth cartilages at sternum; division of cartilages of lower ribs. Interrupted silk sutures. Death on table, after transitory resuscitation of heart by injection of salt solution into left ventricle. Autopsy showed that the heart had been entirely perforated by the knife; tricuspid valve injured; exit orifice 1 cm.

Guidone (*Poli-clinico Sez. Prat.*, vol. xvi, Fasc. 36, 1909, p. 1135): Stab wound of thorax, 1.5 cm. long. Male, age 18 years. Operation soon after injury. Wound of right ventricle. Resection of sternum and fifth, sixth, and seventh costal cartilages. Five interrupted sutures. Pericardium drained. Recovery.

Guinard (*Bull. et Mem. Soc. de Chir. de Paris*, vol. xxxvi, 1910, p. 162): Gunshot wound, third interspace, 1 cm. internal to nipple line. Male, age 13 years. Hæmothorax, 1½ litres. No signs of cardiac injury. Symptoms of progressive internal hemorrhage. Two holes in base of heart. Three catgut sutures to each wound. No trace of blood in pericardium; it gushed directly into the pleura. No drainage. Emphysema. Death three hours after operation.

Heinrichsen (*St. Petersburger Mediz. Wchschrft.*, No. 45, 1910, p.

632) : Stab wound at level of left second rib between margin of sternum and axillary line. Injury to lung. Time between injury and operation, 3 hours. Left ventricle 1 cm. Enlargement of wound, resection of third and fourth ribs. Suture of heart, pericardium, and pleura. Death on second day due to simultaneous injury of lung which had been overlooked.

Heinrichsen (*ibid.*) : Stab wound in third intercostal space, mammary line. Right ventricle through entire wall, 1.5 cm. long. Enlargement of wound, resection of third, fourth, and fifth costal cartilages. Suture of heart, pericardium, and pleura. Purulent pericarditis. Death on twenty-first day.

Heller, quoted by F. Hesse : Stab wound, 5 cm., in fifth intercostal space external to nipple. Male, age 22 years. Hæmopneumothorax. Hæmopericardium. Time between injury and operation, one hour. Left ventricle a few centimetres above apex. Triangular flap, with division of fifth, fourth, and third ribs. Resection of sixth rib. Four silk sutures. Pericardium drained. Pleural cavity drained with large tubes. Much serous discharge. Death on third day.

Houzel (*Gazette des Hopitaux*, No. 3, 1911, p. 32) : Stab wound, 6 cm., left nipple. Male, age 32 years. Over one hour before operation. Auriculoventricular wound, exposing mitral valve, 5 cm. long. Five catgut sutures. No drainage. Heart stopped a few seconds after application of the last suture. Revived, after 12 seconds, by cardiac massage. Two litres of hot serum poured into thoracic cavity. Death 17 hours later.

The following 21 cases operated at Obuchow Hospital, St. Petersburg :

E. Hesse (1905) (*Beitr. z. klin. Chirurgie*, vol. lxxv, H. 3, 1911, p. 475) : Stab wound 3 cm. long, parasternal line, fifth intercostal space. Male, age 19 years. Heart tamponade. Time between injury and operation, 1 hour. Penetrating wound of right ventricle. Flap incision along left sternal margin and fifth rib, base above, resection of sternal segments of fourth, fifth, sixth, and seventh ribs. Three sutures. Drainage of pericardium. Drainage of pleura through wound. Change of dressings on fifth day; tampons soaked. Recovery. Well five years after the operation, with full working capacity.

Ibid. (1906) : Stab wound, 1.5 cm. long, in left third intercostal space, anterior axillary line. Male, age 19 years. Wound of lung near base. Time between injury and operation unknown. Wound 1.5 cm. long in anterior surface of left ventricle about two fingers' width from apex. Incision along third rib; resection of 6 cm. of third rib. Application of heart sutures. Death on table.

Ibid. (1906) : Stab wound, 2 cm. long, on third rib, 2 fingers' width to left of sternum. Male, age 19 years. Time between injury and operation, 6 hours. Small wound of right atrium. Triangular skin-muscle flap. Resection of fourth and third costal cartilages and part of sternum. Three sutures. Drainage of pericardium. Death 42 hours after operation, acute anæmia.

Ibid. (1907): Stab wound between seventh and eighth left ribs. Male, age 20 years. Time between injury and operation, a few hours. Wound of left ventricle near apex, 1 cm. long. Resection of seventh and eighth ribs. Three silk sutures. Pericardium drained with gauze. Pleural cavity drained with gauze. Empyema. Death on eighth day.

Ibid. (1906): Gunshot wound, in third intercostal space, left nipple line. Male, age 31 years. Hæmopericardium. Operation soon after injury. Left ventricle was obliquely opened, part of myocardium torn away. Sutures were applied deeply, but always tore out. Symptoms of progressive heart failure. Death in 24 hours.

Ibid.: Stab wound over left fifth rib between nipple and parasternal lines, 4 cm. long. Male, age 23 years; exsanguinated. Pleura penetrated. Hæmopericardium. Penetrating wound of left auricle, wound 3-4 cm. long. Six sutures. Death on table.

Ibid. (1907): Stab wound in left nipple line between fifth and sixth ribs. Male, age 17 years. Pericardium filled with fluid blood. Immediate operation. Left ventricle 3 cm. long. Enlargement of wound along sixth rib, which was resected for about 10 cm. Second vertical incision, resection of fourth and fifth ribs, extent of 5 cm. Seven sutures. Pericardium drained. Lung was fixed to thoracic wall. Pneumonia and empyema. Death on fifth day.

Ibid. (1907): Three stab wounds, 2-3 cm., near sternum in region of fifth rib. Male, age 23 years. Stab wound opening abdominal cavity. Right ventricle 5 cm. Incision across sternum, along fifth rib, resection of rib. Four sutures. Death on table, after resuscitation by injection of salt solution into left ventricle.

Ibid. (1907): Stab wound between fifth and sixth rib, in left anterior axillary line. Male, age 15 years. Left ventricle, at left margin, near apex, 1.5 cm. Enlargement of wound, partial resection of fourth and fifth ribs with cartilages. Four sutures. Suture of pleura. Pericardium drained with gauze. Death on third day. Acute anæmia.

Ibid. (1908): Stab wound 2 cm. long, between fourth and fifth costal cartilages, 1½ fingers' width to left of sternum. Male, age 21 years. Stab wound of abdomen, viscera uninjured. Time between injury and operation, 1½ hours. Right ventricle, 1 cm. Skin-muscle flap, resection of cartilages of fifth and sixth ribs. Two deep sutures. Pericardium and pleura closed. No drainage. Pneumonia on fifth day. Empyema, thoracotomy on eighth day. Obstinate septic diarrhoea on twelfth day. Dry pericarditis on fifteenth day. Improvement began fifth week. Discharged, in good condition, in eleven weeks. Well two and a half years after operation.

Ibid. (1908): Stab wound, 3.5 cm., near sternum, over second right rib. Male, age 19 years. Right ventricle, 1.5 cm. Resection of second, third, and fourth costal cartilages and part of sternum. Six silk sutures. Pericardium drained. Bilateral pneumonia, left-sided empyema, purulent pericarditis. Death twenty-fifth day.

Ibid. (1909): Gunshot wound between fourth and fifth ribs, 2 fingers' width to right of nipple. Exit orifice about four fingers' width below

left scapular angle. Male, age 17 years. Wound of left lung. Time between injury and operation, $1\frac{1}{2}$ hours. Left ventricle. Resection of fourth and fifth ribs with cartilages, about 7 cm. Three sutures. Suture of lung wound, pericardium, and pleura. No drainage. Left-sided empyema; thoracotomy. Pericarditis sicca. Right-sided dry pleurisy. Recovery. Two years later, in good health. Radiograph showed presence of adhesions.

Ibid. (1909): Stab wound, 2 cm. above and to right of left nipple. Male, age 28 years. Injury of branches of coronary artery. Time between injury and operation, 4 hours. Left ventricle, anterior surface near apex, 1 cm. Resection of fourth rib. Two sutures. Suture of pericardium and pleura. No drainage. Recovery. Eighteen months after operation good health; slight systolic retraction in the cicatrix.

Ibid. (1909): Stab wound, 2 cm. in anterior axillary line between fifth and sixth ribs. Male, age 20 years. Penetrating lung wound. Left ventricle. Resection of fifth rib. Heart sutures cut through. Pericardium was stitched with heart wound. Pericardial attachment then detached from pericardium and pericardium closed. Lung sutured. Death soon after operation.

Ibid. (1910): Stab wound at right sternal margin, over fifth rib. Walked to hospital. Profuse bleeding. Male, age 17 years. Right auricle, 0.5 cm. long, just below entrance of vena cava. Resection of fifth and sixth ribs to extent of 4-5 cm. Four sutures. Closure of pericardium. Partial closure of pleura. Control of pneumothorax by means of Potain apparatus. Death in 17 hours. Symptoms of progressive heart failure.

Ibid. (1910): Stab wound about 1.5 cm. long, between fifth and sixth ribs, left side, between nipple and anterior axillary line. Male, age 27 years. Time between injury and operation, $1\frac{3}{4}$ hours. Left ventricle, 2 cm. long about 5 cm. from cardiac apex. Resection of fourth and fifth ribs, to extent of 6-7 cm. from sternum. Three sutures. Suture of pericardium and pleura. No drainage. Left-sided pneumonia, on fourteenth day. Well on twenty-fifth day. Re-examined 8 months after operation, condition good.

The following five cases have been published in a Russian journal, 1904:

Ibid. (1903): Stab wound 1.5 cm. long in second intercostal space, about $2\frac{1}{2}$ fingers' width from left sternal margin. Female, age 25 years. Time between injury and operation, 3 hours. Left ventricle 0.5 cm. Skin-muscle flap, resection of third and fourth cartilages. One suture. Pericardium and pleura sutured. No drainage. Recovery. Ten and a half months later, in good health. Re-admitted 7 years after operation, no disturbance of heart, systolic retraction of cicatrix.

Ibid. (1903): Stab wound 1.5 cm. long in fourth intercostal space, about $1\frac{1}{2}$ fingers' width to left of left nipple. Female, age 30 years. Complicating injury, fracture of skull. Time between injury and operation, 5 hours. Wound about 1.5 cm. long, anterior wall of right ventricle,

close to anterior branch of coronary artery. Skin-muscle flap. Resection of third, fourth, and fifth ribs. Two sutures. Suture of pericardium and pleura. Pleura drained with gauze through wound. Death in 54 hours. Autopsy showed signs of incipient fibrinous pericarditis and pleurisy, chronic nephritis, and a large cranial fissure.

Ibid. (1903): Stab wound 1.5 cm. long in second intercostal space, 1.5 cm. to left of sternal margin. Female, age 22 years. Time between injury and operation, 4½ hours. Right ventricle, 1.5 cm. near septum, 2½ fingers' width from cardiac apex. Flap of third, fourth, and fifth costal cartilages, division of sixth rib at sternal insertion. Five sutures. Suture of pericardium and pleura. No drainage. Steadily rising temperature and dyspnoea. Resection of ninth rib; escape of bloody fluid and clots. Signs of exudative pericarditis. Death on fourteenth day. Autopsy showed that heart wound had completely healed so that the sutures could only be discovered with difficulty.

Ibid. (1903): Stab wound 3.5 cm. long in fourth intercostal space in left parasternal line. Female, age 53 years. Irregular stellate wound in left ventricle, diameter about 2.5 cm. Resection of cartilage and bone of fifth rib, and cartilage of fourth rib, close to sternum. Seven sutures. Death on table. Heart massage unsuccessful.

Ibid. (1904): Stab wound, 1 cm. long, in fourth intercostal space, at right sternal margin. Female, age 35 years. Time between injury and operation, 1 hour. Two transverse wounds of right auricle, about 0.5 cm. long, one below the other. Flap, lateral pedicle of fourth, fifth, and sixth cartilages. Closure of upper heart wound, 1 suture; lower heart wound, 2 sutures. Drainage of pleural cavity, through wound. Death 29 hours after operation.

F. Hesse (1908) (*Archiv f. klin. Chir.*, vol. xcv, H. 4, 1911): Gun-shot wound, third left intercostal space, 2 cm. inside nipple line. Male, age 15 years. Hæmopericardium. Time between injury and operation, 1½ hours. Middle of left ventricle 2 cm. to right of margin, orifices on anterior and posterior surfaces. Skin-muscle bone flap base medial including third and fourth cartilages. One and two silk sutures. Rubber drain in pericardium. Two drainage tubes in pleural cavity, scapular line, by resection of rib. Death in seven hours. Heart stopped during the operation; massage failed; injection of camphor 0.75 cm. 20 per cent. solution into heart muscle effective.

F. Hesse, *ibid.* (1909): Stab wound, 1 cm. in length in third left intercostal space, 4 fingers' width from sternum. Male, age 35 years. Time between injury and operation, nearly 3 hours. Left auricle 0.75 cm. long. Resection of ribs and cartilages, also a strip of sternum. Effort to do extrapleural operation failed. Three silk sutures. Large rubber drainage tube into pericardium. Two drainage tubes into pleural cavity in scapular line by resection of rib. Discharge from pleural cavity profuse, from pericardial cavity slight, so that drain was removed on fifth day. Pleural drain left for a month. Recovery. Two years later slight systolic retraction in fifth intercostal space, within nipple line.

F. Hesse, *ibid.* (1909): Stab wound 1 cm. long in third left inter-

costal space near sternum. Male, age 24 years. Pronounced tamponade. Time between injury and operation, 2½ hours. Left auricle, 0.75 cm. Flap with external pedicle of third and fourth cartilages and part of ribs; resection of half of adjacent sternum; section of fifth rib. Pleura opened. Three silk sutures. No drainage. Recovery. Two years later complained of pain after exertion. Distinct systolic retraction in fifth intercostal space.

F. Hesse, *ibid.* (1909): Stab wound, 2.5 cm. long, under left nipple, in fourth intercostal space. Male, age 17 years. Hæmopneumothorax. Time between injury and operation, 3 hours. Left ventricle a little below atrioventricular boundary. Resection of fourth rib from nipple to sternum; opening of pleura to this extent. Five silk sutures. Removal of clots from pleural cavity. No drainage. Pleurisy and pneumonia. Entire wound opened and healed gradually. Recovery. Ten months later free from any disturbance due to the injury.

Iselin (*Deutsch. Ztschrift. f. Chir.*, vol. cv, 1910, p. 572): Gunshot wound, in fourth intercostal space, mesial to nipple. Female, age 20 years. Small wounds in lung. Hæmothorax. Hæmopericardium. Time between injury and operation, 1¾ hours. Small hole in left ventricle, nearer to base than apex. Exit orifice posteriorly, a little larger. Intercostal incision in fourth space beyond anterior axillary line. Suture of both heart wounds with catgut. Suture of lung wounds. Suture of pericardium and pleura after removal of clots. No drainage. Moderate symptoms of pericarditis and pleurisy. Recovery.

Einar Key (*Hadar Liden Hygeia*, vol. lxxi, 1909, p. 1249): Gunshot wound of epigastrium. Boy, age 10 years. Operation 1 hour after injury. Oval wound 1 cm. long in anterior surface of right ventricle, near apex. Incision through wound in epigastric angle, upward through sternal ends of sixth, to fourth left costal cartilages; transverse incision in sixth intercostal space, forming a thoracic flap with its base above. Closure of heart wound with interrupted catgut sutures. Pericardium drained with small tampon which was removed on next day. Drainage of pleural cavity. Empyema. Recovery. Radiograph showed bullet in left wall of thorax.

Kirchner (*Southern Surg. and Gyn. Transactions*, xxii, 1909, p. 171): Two stab wounds in fifth and sixth intercostal spaces about ½ inch in length. Male, age 37 years. Pericardium contained fluid blood. Left ventricle, ¾ inch, near apex. Osteoplastic flap with mesial pedicle at sternum, division of sixth rib. Eight silk sutures. Gauze drain in pericardium. Pleural cavity drained with rubber tube. Death four hours after operation. Autopsy showed another small wound in left ventricle.

Kirchner (*ibid.*): Stab wound ¾ inch, in fifth intercostal space. Male, age 24 years. Time between injury and operation, ½ hour. Left ventricle, 1¾ inches long, 1 inch from apex. Osteoplastic flap, pedicle at sternum. Three deep chromic catgut sutures. Seven intermediate sutures required to control hemorrhage. Two supporting mattress sutures. Rubber drain in pericardium. Pneumonia. Recovery.

Leischner, cf. Ranzi.

McCabe (*Southern Med. Journal*, 1910, p. 540): Stab wound in fourth intercostal space. Female, age 18 years. Time between injury and operation, 2 hours. Right ventricle near centre. Enlargement of original wound, division of fourth costal cartilage. Catgut sutures. Drainage tube into pericardium. Pneumothorax and pneumonia. Death on seventh day.

Magenau (*Beitr. s. klin. Chir.*, vol. lxxix, 1910): Gunshot wound slightly mesial to nipple. Male, age 28 years. Hæmothorax. Hæmopericardium. Time between injury and operation, 2 hours. Left ventricle circular wound 1 cm. in diameter, 3 fingers' width above apex. Oval wound on posterior surface. Resection of segments of sixth, fifth, and fourth ribs. Three sutures of linen for each wound. No drainage. Second day pulse gradually disappeared. Pericardium was opened, and much turbid serous exudate escaped. Pulse returned, but patient died suddenly.

Neugebauer (*Münch. med. Woch.*, No. 1, 1909, p. 25): Stab wound 1.5 cm. long above left third costal cartilage near sternal margin. Male, age 21 years. Hæmopericardium. Time between injury and operation, 6 hours. Pericardium was aspirated $\frac{1}{2}$ hour after admission; temporary relief. Right ventricle middle of anterior wall, 1.5 cm. Flap of third, fourth, and fifth left costal cartilages. Removal of half of adjacent sternum. Five silk sutures. Pericardium drained. Change of dressings on second day; escape of large quantity of clear serum, synchronous with heart beats; continued discharge of clear serum for several days. Recovery. Well two months after discharge, heart normal.

Pikin (*Archiv f. klin. Chir.*, vol. xcv, 1911): Stab wounds with scissors, in thoracic region. Female, age 23 years. Wounds of both lungs, liver and diaphragm. Hæmopneumothorax. Left auricle 1.25 cm. Enlargement of pericardial wound to 6 cm. Closure of heart wound with 2 silk sutures. Closure of pericardium with interrupted catgut suture. No drainage. Bilateral serous pleuritis. Recovery.

Pool: Stab wound, $\frac{1}{2}$ inch long, fourth intercostal space just mesial to nipple. Male, 24 years old. Pleural cavity penetrated by knife. Operation less than 1 hour after injury. Left ventricle at margin, $\frac{1}{2}$ inch long, $1\frac{1}{2}$ inches above apex. Flap with lateral pedicle, including third and fourth costal cartilages; section of fifth cartilage. Five vaselined silk sutures in heart wound. Pericardium closed with interrupted catgut, leaving space at lowermost part for drainage. Rubber tissue drain to but not into pericardial wound at lower mesial angle of wound. Free serous discharge for seven days. Up on eighteenth day, discharged on twenty-fifth day. Recovery.

Proust, Bloch, de Cumont. (*Bull. d. l. Societe Anat. de Paris*, vol. lxxxv, 1910, p. 635): Gunshot wound, mesial to left nipple; fifth costal cartilage fractured by bullet. Boy, age 13 years. Pleura opened. Pericardium filled with clots. Time between injury and operation, 6 hours. Left ventricle near apex. Flap formation, division of fourth to sixth cartilages at sternal insertion; four sutures. Very small drain into pericardium. High temperature. Symptoms of pericardial effusion

second week. Nothing drained from tube, which was drawn out, and a large quantity of bloody serous fluid escaped; improvement; temperature normal in less than 48 hours. Patient discharged well one month after operation. Seen two months later in good health.

Ranzi (*Wiener klin. Woch.*, No. 50, 1911, p. 1729): Two gunshot wounds over fifth and sixth left ribs mesial to nipple. Male, 24 years old. Hæmothorax. Time between injury and operation, 5 hours. Left ventricle anterior surface near apex; no exit wound found. Schoenmaker's hyperpressure apparatus used. Skin-muscle flap, resection of fourth and fifth cartilages. Several sutures. No drainage. Empyema; posterior thoracotomy. Recovery.

The following 3 cases, previously unpublished, were likewise operated on in V. Eiselsberg's Clinic.

Ranzi (*ibid.*): Stab wound above left nipple. Female, 20 years old. Moribund. Hæmopericardium. Time between injury and operation, 40 minutes. Left ventricle 1 cm. Sauerbruch's cabinet. Resection of 8 cm. fifth and sixth ribs. Six sutures. No anaesthesia. Death on table.

Leischner (*ibid.*): Gunshot wound 2 fingers' width mesial and below left nipple. Male, 17 years old. Hæmothorax. Two wounds of lung. Time between injury and operation, 1 hour. Near septum 2 fingers' width above apex. Sauerbruch's cabinet. Skin-muscle flap. Resection of fourth and fifth ribs. Three sutures. Lung wounds sutured. Camphor and adrenalin injections into left ventricle. No drainage. Cough with hæmoptysis. Death on second day.

Ehrlich (*ibid.*): Stab wound below and mesial to left nipple. Hæmopericardium marked. Operation 45 minutes after injury. Anterior wall of right ventricle, 2 wounds. Resection of 4 cm. of fourth and fifth ribs. Eversion of third cartilage. Suture of heart wounds. No drainage. Death on day after operation. Autopsy showed another wound on posterior surface of left ventricle.

Rassieur (1903) (*J. Missouri Med. Assoc.*, St. Louis, 1910, vol. vi, p. 316): Gunshot wound in fourth space just below and internal to left nipple. Male, age 20 years. Left lung wounded in lower lobe. Hæmothorax. Time between injury and operation, 3 hours. Left ventricle, ragged laceration midway between base and apex. Resection of one inch of fourth and fifth ribs at costochondral junction. Three silk sutures. Repair of wound of lung. No drainage of pericardium. Gauze drain in pleural cavity. Late secondary abscess. Recovery.

Renner (*Deutsch. med. Woch.*, No. 10, 1910, p. 456): Two stab wounds, one in fifth intercostal space, 3 cm. long, one in sixth intercostal space, 8 cm. long. Male, age 32 years. Wound involved pleura, diaphragm, and peritoneum. Operation $\frac{1}{2}$ hour after injury. Left ventricle 2 cm. long. Flap of third, fourth, fifth, and sixth ribs. Four silk sutures. Suture of diaphragm. Pericardium and pleura drained with rubber tubes. During first days, profuse serous secretion. Pericardial drain removed on ninth day; pleural drain on thirteenth day. Recovery. Patient in good condition nine months later. Renner recommends extensive drainage with tubes.

Schmerz (*Mittlg. d. Vereins der Aertze in Steiermark*, Nov., 1911,

p. 415): Stab wound 2 cm. long in fourth space at upper margin of fifth rib near sternum. Male, age 21 years. Pleura opened. Operation soon after injury. Right ventricle 2 cm. Skin-muscle flap. Fourth and fifth ribs with cartilages resected 7 cm. Four silk sutures. Pericardial and pleural cavities flushed with salt solution. Lower margin of lung sutured into pleural wound. Gauze drain to pericardial suture. No pleural drainage. Serous pleuritic exudate, twice tapped. Free serous discharge from drainage opening. Recovery.

Schnitzler (*Wiener med. Woch.*, No. 7, 1910, p. 386): Stab wound near left nipple, 1.5 cm. long. Male, age 16 years. Left pleura opened by weapon. Time between injury and operation, $\frac{3}{4}$ hour. Right ventricle near septum about middle of anterior wall 1 cm. long. Removal of 3 cm. of fourth and fifth costal cartilages. Four silk sutures. Pericardium not drained. Gauze and drainage tube into pleural cavity. (Pleura could not be closed on account of tension.) Left-sided hæmopneumothorax. Right-sided pneumonia. Recovery. Schnitzler mentions, without details, two unsuccessful cardiorrhaphies in his experience.

Schoenborn (1903), quoted by F. Hesse: Stab wound in sixth left intercostal space, 0.5 cm. long. Adult male. Pericardium contained masses of fluid blood and clots. Operation a few hours after injury. Left ventricle. Partial resection of sixth rib. Triangular flap, resection of cartilages and segments of fifth, fourth, and third ribs. Pleura accidentally opened. Four catgut sutures. Drainage of pericardium and pleural cavity. Death on second day. Autopsy showed that the catgut sutures were already so loose that they would probably have given way. No hemorrhage.

Schoemaker (*Monatsschrift f. Unfallheilkd.*, vol. xvi, 1909, p. 225): Stab wound 2 cm. long, close to sternum, over cartilage of sixth left rib. Male, age 26 years. Hæmopericardium. Operation 2 hours after injury. Right auricle. Triangular flap; 5 cm. of sixth cartilage removed; vertical incision along edge of sternum 6 cm. long, dividing fifth and fourth cartilages. Three catgut sutures. Pleura sutured. Pericardium drained with gauze. Removal of drain on third day was followed by large quantity of clear serum, which ceased two days later. Recovery.

Tavel (1909), quoted by König (*Deutsch. Zeitschft. f. Chir.*, Bd. cxii, H. 4-6, 1911, p. 490): Stab wound, fifth intercostal space, 2 fingers' width outside mammary line, 1.5 cm. Male, 22 years old. No increase in cardiac dulness. Pleura penetrated but no signs of hæmothorax. Time between injury and operation $1\frac{1}{2}$ hours. Apex 1.5 cm. long. Flap with mesial base of fourth, fifth, and sixth cartilages and ribs which were divided 2 fingers' breadth external to mammary line. Three catgut sutures. Suture of pleura. Gauze drain to pleura suture. Pericarditic friction. Bronchopneumonia. Up in 4 weeks. Recovery.

Torre, de la Ortiz (*Rev. d. Med. y. Cir. pract. de Madrid*, 1908; *Centralblatt f. Chir.*, No. 49, 1908, p. 1488): Wound in fourth intercostal space, 2 cm. Adult male. Right auricle contained an imbedded piece of glass. Flap of 10 cm. of fourth, fifth, and sixth ribs. Catgut suture. Rise of temperature on fifth day. Evacuation of 700 Gm. of fluid, by puncture. Recovery.

Trendelenburg (Rimann, *Münch. med. Woch.*, No. 15, 1909, p. 760): Gunshot wound, in fourth left intercostal space. Male, age 20 years. Pericardium contained 100 c.c. of fluid and clotted blood. Time between injury and operation about 1¼ hours. Left ventricle, small hole in lower half. No exit orifice found. Longitudinal incision on fifth rib, resection of fourth and fifth costal cartilages. Five silk sutures. Excision of gunshot wound in skin. No drainage. Course favorable. Recovery.

Walther (*Protokolle d. Wissenschft. Veriens der Aerzte des Städtischen Obuchow Krankenhauses*, St. Petersburg, Nov. 13, 1909): Stab wound in cardiac region. Right ventricle. Heart suture. Recovery. Death from cardiac insufficiency three years and eight months after the operation. Autopsy: Extensive cardiopericardial adhesions. Heart wall very thin in region of cicatrix. No aneurism.

Wesselowsorow (*K. Kaukasian Med. Gesellscht.*, 1910; quoted by E. Hesse, *Beitr. z. klin. Chir.*, 75, 1911): Heart suture. Recovery.

E. Rychlik: Herzverletzung (*Sbornik klinicky*, 1911, xii [xvii], Nr. 3 u. 4) (*Zentralblatt für Chirurgie*, No. 6, Feb. 10, 1912, p. 206): The author reports five cases of wound of the left ventricle.

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