Staphylococcal Infections of the Heart and Great Vessels Due to Silk Sutures *

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ONE of the uncommon but anticipated problems of surgery of the cardiovascular system is bacterial infection. It is the purpose of this report to review five cases of postoperative infection of the myocardium and great vessels which demonstrate certain features in common. In all five, silk sutures constituted a site of minimal resistance to infection, and in each, the definitive therapeutic maneuver was re-operation and removal of the foreign body.

CASE REPORTS

Case 1. (Fig. 1): M. R., JHH 563612, a 23-year-old mother from rural Maryland, had first noted dyspnea on exertion at the age of 17 and probably had experienced an episode of pulmonary edema at the age of 21. During a pregnancy at the age of 22, she had been discovered to have a patent ductus arteriosus, and she was digitalized. At the time of admission to the Johns Hopkins Hospital, blood pressure was 115/30 and pulses were collapsing. The heart was enlarged to the left and a characteristic machinery murmur and accompanying thrill were noted over the left upper chest anteriorly. Fluoroscopically, cardiac and aortic pulsations were vigorous and pulmonary vascular markings were accentuated.

Thoracotomy on October 6, 1951, revealed a patent ductus arteriosus 12 mm. in diameter which was treated by suture-ligation, purse-string sutures being placed at each end of the ductus with transfixion sutures between. Convalescence was uneventful. She was given tetracycline for 13 days and discharged on October 24, afebrile and free of murmurs. About six weeks after operation she experienced chills, fever, fatigue, and anorexia and noted dark urine. In the ensuing month, she developed albuminuria and remained febrile with peaks of 102° F. despite a ten day course of aureomycin given by her local physician. She was rehospitalized on December 29, 1951.

Blood pressure was 110/50 with sounds audible to zero; there was increased cardiomegaly, and the continuous murmur was again audible under the left clavicle. Several blood cultures were positive for hemolytic Staphylococcus aureus, sensitive to penicillin. She was started on 6.4 million units of intramuscular penicillin daily with 2 Gm. of Benemid® and defervesced within 48 hours, blood cultures becoming sterile. A second thoracotomy was performed on January 26, 1952. The aorta and pulmonary artery were mobilized and temporarily occluded while a small aneurysm in the region of the recanalized ductus was excised. The silk sutures that had been placed at the first operation were found in the aneurysm immediately adjacent to the ductus. There were vegetations in the pulmonary end of the recanalized vessel, which was divided and the ends closed with interrupted sutures of silk. Pericardium was sutured over the pulmonary artery, separating it

* Presented before the American Surgical Association, Chicago, May 8–10, 1957.

Aided by Grant H-226 from the National Heart Institute, Public Health Service.

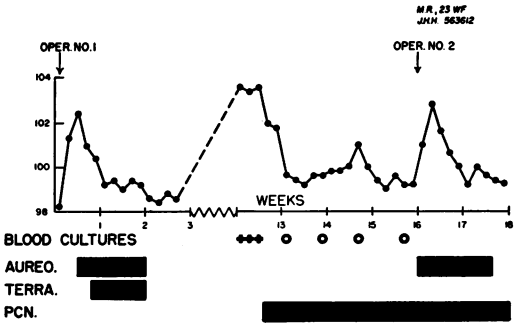

FIG. 1. Clinical course in Case 1.

from the aortic suture line. Penicillin was continued for three weeks postoperatively and she was discharged afebrile. She has remained well since and delivered a normal baby in May 1954.

Summary: A 23-year-old mother with a patent ductus arteriosus was treated by suture-ligation uneventfully. Signs of infection in the region of the ductus occurred six weeks later, associated with bacteremia due to hemolytic Staphylococcus aureus, recanalization and formation of a small aneurysm of the ductus. Treatment with penicillin with later removal of the sutures and closure of the aortopulmonary communication brought about complete cure.

Case 2. (Fig. 2): G. W., JHH 657098, a 34-year-old housewife, was referred to the Johns Hopkins Hospital because of dyspnea and a right cervical mass. One year previously she had noted intermittent distention of the cervical veins and pain in the right side of the head and neck. Three months before admission, a mass had appeared in the lower cervical region and the patient had experienced increasing dyspnea, orthopnea, and mild dysphagia. On admission the blood pressure was 140/90; she was dyspneic at rest and preferred to lie with the head elevated. The cervical veins were engorged and there was a pulsatile, tender mass in the right supraclavicular region. Serologic tests for syphilis were positive, and an aortogram confirmed the presence of an aneurysm of the innominate artery. On November 27, 1953, exploration was performed through an incision in the right third intercostal space and median sternotomy. During mobilization of the vessels proximal and distal to the aneurysm, rupture occurred. The greater curvature of the aortic arch was clamped, the aneurysm was excised, and the area was sutured rapidly. It was thought at the time that both common carotid arteries had been occluded and that both arose from the aneurysm; hence the usual removal of necrotic tissue was not done. Postoperatively it was evident that only the right common carotid had been occluded as the left carotid pulse was easily palpable; she awakened normally and showed no neurologic deficit. She was given 2.4 million units of penicillin and 2 Gm. of streptomycin daily for eight days. There were profuse tracheobronchial secretions; fever reached a peak of 103.6° on the third postoperative day, and she was afebrile after the sixth day.

She remained well for five and one-half months when there was an abrupt onset of pain, swelling, and redness in the right sternoclavicular region with fever and orthopena. She was readmitted May 17, 1954, and found to have a soft, fluctuant, tender mass in the right lower neck. Several milliliters of serosanguinous fluid were aspirated by needle from the mass on six occasions. Cultures revealed a hemolytic

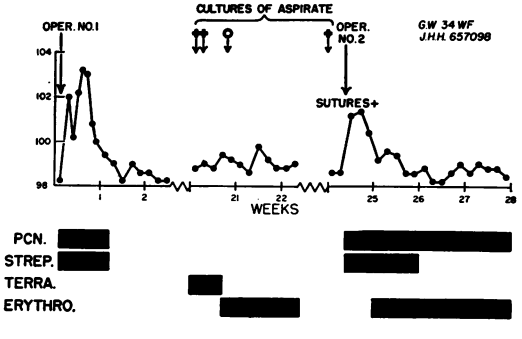

FIG. 2. Clinical course in Case 2.

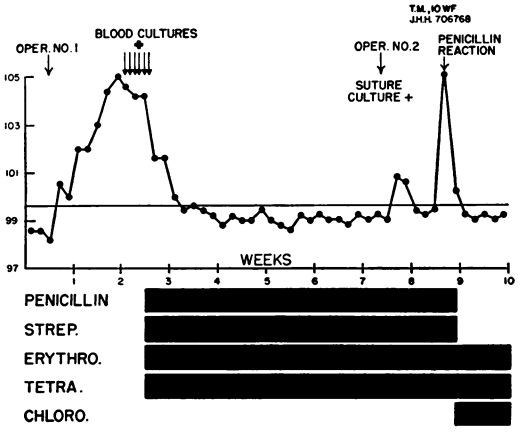

FIG. 3. Clinical course in Case 3.

Staphylococcus albus which was sensitive to erythromycin and penicillin. She was given 2 Gm. of erythromycin daily and there was diminution in swelling and tenderness; culture of aspirated fluid was sterile. She was discharged for about a week but the mass again enlarged and spontaneous bleeding occurred at the site on May 12. She was explored immediately. The incision was reopened and ribs and right clavicle removed. The cervical abscess was found to extend to the aorta where a rupture had occurred. The first portion of the greater curvature of the aortic arch was clamped to control hemorrhage. A number of silk sutures were found lying free in the region of the aorta. These were removed, the aortic opening was closed with two rows of 6-0 twisted stainless steel wire, and the adjacent area was cleaned of necrotic material. After operation she was given 12 million units of penicillin and 2 Gm. of streptomycin daily for 12 days at which time streptomycin was stopped and penicillin dosage was reduced to 1.8 million daily. On the seventh day, a daily dose of 1.5 Gm. of erythromycin was added to the regimen. Penicillin and erythromycin were continued for four weeks. She defervesced after a week and remained afebrile. Cultures of the silk and tissues removed at operation grew hemolytic Staphylococcus albus. The patient was free of recurrence when last seen in April 1957.

Summary: A 34-year-old woman with an innominate aneurysm, probably due to syphilis, was treated by excision. Infection by Staphylococcus albus and recurrence of the aneurysm complicated by hemorrhage five and one-half months later was successfully treated by removal of the silk and necrotic tissue and resuture of the aorta with stainless steel wire.

Case 3. (Fig. 3): T. M., JHH 706768, a ten-year-old girl, was known to have a heart murmur at birth but had been otherwise normal. Examination showed blood pressure of 110/60 with sounds audible to zero and a continuous murmur typical of patent ductus arteriosus. By fluoroscopy, the cardiothoracic ratio was 58 per cent, pulmonary vascular markings were increased, and there were prominent hilar pulsations. Electrocardiogram showed a normal axis with left ventricular hypertrophy. On June 8, 1955, interruption of the patent ductus arteriosus was performed by placing a purse-string suture at each end of the ductus and a transfixion suture between; all three sutures were of 00 silk. Postoperatively she received 1.2 million units of penicillin and 1 Gm. of streptomycin daily. Because of possible drug fever of 102° F. on the seventh postoperative day, antibiotics were temporarily stopped. However, the patient continued to have fever and the continuous murmur reappeared below the left clavicle 12 days after operation. On the thirteenth day, blood cultures grew hemolytic Staphylococcus aureus which was sensitive to 5 units of penicillin per milliliter, 52 mcg. of tetracycline, 10 mcg. of erythromycin, and 10 mcg. of Chloromycetin® per milliliter. She was begun on 6 million units of penicillin (intravenously for the first 2 weeks), 1 Gm. of Benemid®, 1 Gm. of streptomycin, 1 Gm. of tetracycline, and 0.8 Gm. of erythromycin daily, and this

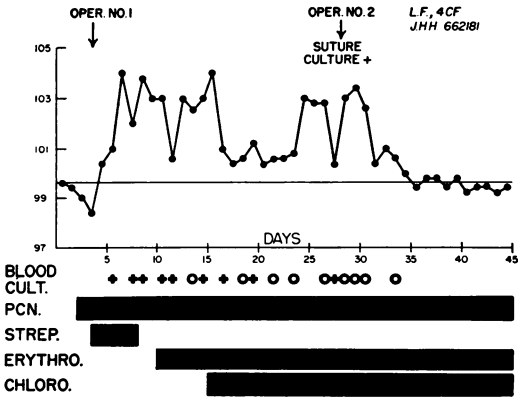

FIG. 4. Clinical course in Case 4.

regimen was continued for six weeks. She had intermittent hematuria and fever but defervesence occurred within two weeks and she became asymptomatic. Roentgenograms showed progressive widening of the superior mediastinum by a mass in the region of the ductus. During the six weeks of intensive antibiotic treatment, repeated tests showed that the patient's serum would kill the staphylococcus isolated from her blood in a dilution of 1 : 64.

On August 8, thoracotomy was performed; an 8 cm. aneurysm was found in the region of the recanalized ductus. Aorta and pulmonary artery were mobilized and temporarily occluded (the aorta for seven minutes, the pulmonary artery for 40 minutes), the aneurysm was opened and the three silk sutures removed. 6-0 twisted stainless steel wire was used to close the aorta and 5-0 arterial silk for the pulmonary artery. Cultures of the silk sutures grew hemolytic Staphylococcus aureus. This organism was sensitive to penicillin and the other drugs that had been administered. Except for a rise to 101.4° F. on the day following operation, she was afebrile until the sixth postoperative day when a rash appeared which was treated with Pyribenzamine®. The following day she was febrile to 105° F., and had a generalized seizure. Penicillin was stopped with prompt subsidence of fever and rash. She was given erythromycin and Chloromycetin® for 18 days more, and there was no recurrence of fever. She improved rapidly and has remained well since.

Summary: A 10-year-old girl with an uncomplicated patent ductus arteriosus developed an infection in the early postoperative period with subsequent recanalization of the ductus. Culture of silk sutures removed at operation six weeks after intensive chemotherapy were positive for Staphylococcus aureus. Reinterruption of the recurrent ductus and removal of silk sutures resulted in cure.

Case 4. (Fig. 4): L. F., JHH 662181, a 4-year-old girl, was first hospitalized at eight months of age for pneumonia and was found to have a systolic murmur and heart failure. Digitalis was begun and continued for about a year. Subsequently cardiomegaly appeared and she was dyspneic after strenuous exertion. Examination showed enlargement of the heart to left and right, a precordial systolic murmur, and a short apical diastolic murmur. On fluoroscopy, the right atrium was enlarged; the pulmonary conus was full and active, and hilar vascular markings were increased. Angiocardiography and cardiac catheterization were typical of auricular septal defect with a large left to right shunt and a small right to left shunt. At exploration on January 13, 1956, there was no posterior rim to the auricular defect; the superior pulmonary vein entered just behind the superior vena cava and the right inferior pulmonary vein behind the inferior cava. Under guidance from a finger passed through the auricular appendage the posterior edge of the auricular septum was grasped by needles inserted from the posterior aspect of the atrium and the edge of the septum was approximated to the posterior wall with three sutures. The upper portion was satisfactorily repaired but the lower end could not be sutured without occluding the inferior cava in spite of considerable effort and

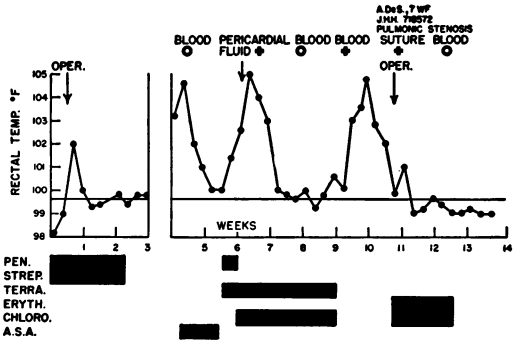

FIG. 5. Clinical course in Case 5.

the attempted placement of five or six sutures. She was left with a small defect in the caudal portion of the repaired septum near the site of entry of the inferior vena cava and the right inferior pulmonary vein. After operation she was given 600,000 units of penicillin, intramuscularly, and 400 mg. of streptomycin daily. Because of hectic fever in the early postoperative period, 1 Gm. of tetracycline was added to the regimen on the fourth day. The first of several blood cultures grew Staphylococcus aureus on the second day. This organism was sensitive to 30 units of penicillin per milliliter and inhibited by 1 mcg. of erythromycin and 10 mcg. of Chloromycetin® per milliliter. She was given 10 million units of penicillin and 300 milligrams of erythromycin intravenously and 500 mg. of Chloromycetin® intramuscularly. She became afebrile, but blood cultures were intermittently positive as late as 13 days after institution of this regimen. The staphylococcus isolated from the blood was killed by the patient's serum in a dilution of 1 : 32 throughout this period.

On February 3, twenty-one days after the first operation, thoracotomy was performed for removal of silk sutures. There was granulation tissue about the middle one of three sutures in the posterior wall of the left atrium. In addition to these sutures, four were removed from the auricular appendage. All of the silk sutures were cultured and grew Staphylococcus aureus. Transient bacteremia recurred during the first hour after operation. She became afebrile on her fourth postoperative day. Twenty million units of penicillin, 0.6 Gm. of streptomycin, and 1.2 Gm. of Chloromycetin® were given daily, the penicillin being reduced to 2.4 million units on the eleventh day. She remained well until the twentieth postoperative day when she developed mumps (a result of nosocomial exposure). Antibiotics were stopped, she remained afebrile and asymptomatic and was discharged one week later. She remained free of infection but died one year later following an attempt to complete repair of the defect under direct vision.

Summary: A four-year-old girl with an auricular septal defect developed fever and positive blood cultures (Staphylococcus aureus) shortly after attempted repair by a closed method. Staphylococcus was grown from silk sutures in the heart in spite of intensive treatment with antibiotics. The infection was controlled only after removal of the infected silk sutures.

Case 5. (Fig. 5): A. DeS., JHH 718572, a seven-year-old girl, had had a loud systolic murmur since birth and had been blue about the lips since the age of 11 months. She had had easy fatigability, dyspnea on mild exertion, frequent colds, and several episodes of syncope. There was right ventricular enlargement and a systolic murmur, accompanied by a thrill which was present in the second and third interspaces at the left sternal border. The lungs were relatively avascular by fluoroscopy. Electrocardiogram showed a right axis deviation and right ventricular hypertrophy. The femoral arterial oxygen saturation was 91 per cent, and cardiac catheterization showed a pressure gradient across the pulmonary valve from 218 mm. Hg systolic in the ventricle to a mean of 6 mm. in the pulmonary artery.

On March 7, 1956, a transventricular pul-

monary valvotomy was performed, a Potts knife and dilator being used. Right ventricular pressure fell immediately from 160 to 85 systolic, and the pulmonary artery pressure rose from 27 to 57. She was given 200,000 units of penicillin and 0.4 Gm. streptomycin daily for ten days, and was discharged on the nineteenth day. Four days after discharge, a white blood count and temperature were normal. The following day, she felt chilly and developed fever of 102° F. She was rehospitalized on the twenty-sixth postoperative day. The heart was enlarged to the anterior axillary line, the systolic murmur in the third and fourth left intercostal space was still present and there was also an early, short diastolic murmur in this area. She was given aspirin and observed. Twelve blood cultures were sterile but on the fortieth postoperative day, pericardial aspiration was performed because of radiologic evidence of cardiac enlargement. A small amount of serosanguinous fluid was obtained which was cultured and grew hemolytic Staphylococcus aureus. This organism was resistant to 250 units of penicillin per milliliter and was inhibited by 1 mcg. of erythromycin and 10 mcg. of Chloromycetin® per milliliter. She was given 0.8 Gm. of erythromycin and 0.5 Gm. of Chloromycetin® daily for 20 days. During this time, her serum in a dilution of 1 : 32 was bactericidal for the staphylococcus isolated from the pericardium. Two subsequent pericardial aspirations yielded small amounts of sterile fluid and she remained afebrile. However, on the day after antibiotics were stopped, her temperature rose abruptly to 105° F. and one of seven blood cultures taken during the next 48 hours grew hemolytic Staphylococcus aureus. Thoracotomy was performed on May 19, and a figure-of-eight silk suture was removed from the site of the ventriculotomy wound along with granulation tissue about it. The suture was easily removed as it lay freely in a sinus. Cultures were taken of subcutaneous fat, intercostal muscle, pericardium, epicardium, myocardium, and silk suture. Only the suture grew Staphylococcus aureus. A portion of the anterior pericardium was excised. Two Gm. each of erythromycin and Chloromycetin® were given daily for the next 12 days. She was afebrile by the second postoperative day, and her subsequent course has been free of infection.

Summary: A seven-year-old girl with pulmonary valvular stenosis was treated by transventricular valvotomy. Postoperative staphylococcal pericarditis appeared to respond to antibiotics but recurred after cessation of treatment and transient bacteremia occurred. The infection was readily cured by removal of a single infected silk suture at the site of the ventriculotomy.

DISCUSSION

Because abnormalities of the heart and great vessels, particularly valvular deformities, shunts, or other sites of intravascular turbulence predispose to local infection by way of the blood stream, it is not surprising that previous descriptions of postoperative cardiovascular infection have emphasized this mechanism.[6] Indeed, this emphasis is obviously correct in instances of valvular endocarditis after mitral commissurotomy when infection of the manipulated valve has been proven.[2]

Persistence of local bacterial infection in the presence of a foreign body is even more familiar. The specific occurrence of infected silk granulomas in operative wounds and their prompt eradication by simple removal of the suture material is well recognized. It is surprising that so little attention has been paid to silk suture as the cause of persistence of infection after cardiovascular surgery. In one of the cases reported by Fleming and Seal [6] there was a staphylococcal abscess containing sutures, in the myocardium, without valvular infection, and in another case infection of the sutured atriotomy may have seeded the valvular infection. In a number of reported instances

of recurrence of patent ductus, silk sutures have been found in false aneurysms at the site of recurrence.[4, 8, 9, 11]

In the five cases reviewed here, postoperative infection clearly consisted of stitch abscesses around silk sutures in the heart or great vessels. The importance of recognition of this type of infection rests in the extraordinary resistance of the infecting bacteria to antimicrobial drugs while the foreign body remains as a nidus and the prompt cure that can be achieved when the sutures are removed. In Cases 1 and 3, in addition to removal of the infected silk sutures, the recanalized ductus was divided, but in the remaining three cases nothing of significance was done other than removal of the foreign body.

Although the precise mechanisms responsible for persistence and resistance of infection around a foreign body are not known, the situation resembles the resistance of localized suppurations and abscesses to chemotherapy without drainage. The studies of Eagle [3] and of Smith and Wood [10] have shown clearly that the unfavorable environment that suppuration provides for phagocytes and for bacterial multiplication is important in the failure of chemotherapy alone. The bactericidal action of penicillin is exerted only against actively multiplying cultures, a situation that does not obtain in the center of an abscess.

It is not possible to state with certainty the route of infection in all of the cases presented. It is entirely possible that the source of the organisms was a transient postoperative bacteremia owing to staphylococci and that localization occurred because of focal lowering of resistance at the sutured sites, but it seems more likely that infection was introduced directly at operation.

The increasing problem of nosocomial staphylococcal infection needs no emphasis here.[7] Furthermore, Elek [5] has shown in human experiments a ten thousandfold potentiation when inoculation of small numbers of staphylococci was made with a silk suture. The fact that staphylococcus was the offending organism in all five cases in addition to the specific localization of infection around sutures (demonstrated so clearly by the cultural studies in Case 5) makes it far more likely that contamination of sutures occurred at operation.

The "lag-periods" between operation and onset of clinical manifestations of infection of six weeks and five and one-half months respectively in Cases 1 and 2 may well represent the suppressive effect of antibiotics given postoperatively. This attenuating action of antibiotics and their conversion of localized infection to a dormant state with subsequent relapse has been emphasized recently in the pathogenesis of subphrenic abscess as a "late" complication of laparotomy.[1]

The apparent response to treatment of infection with antibiotics in several of these patients with relapse when the drugs were stopped seems to constitute an important part of the clinical picture of this complication of cardiovascular surgery and it was this type of course that led to re-operation in Cases 4 and 5.

There is general agreement that the incidence of surgical infections is related to the number of individuals in the operating room, agitation of air, etc. The importance of this factor in modern cardiac surgery is evident from the size of teams required to carry out open surgery with artificial pump-oxygenators as the method is currently employed. In an effort to find out whether the composition of sutures used is important in producing infection when minimal contamination occurs, the reaction to several materials implanted in the right ventricular myocardium of dogs has been studied. In the presence of minimal contamination by staphylococci, silk, stainless steel, nylon, dacron, and catgut sutures led to the formation of infected granulomas from which organisms could be cultured for as long as six weeks. Of great interest is the fact that

the infections associated with catgut have been observed regularly to subside and to heal spontaneously after three weeks, presumably because of the gradual absorption of the foreign body. A great deal more evidence will be needed before the use of catgut sutures can be recommended for cardiovascular surgery, however, particularly in view of the great emphasis on the use of silk that has emanated from this institution.

SUMMARY

Five cases of staphylococcal stitch abscess of the myocardium or great vessels following surgical procedures have een presented. The clinical characteristics of this complication were discussed. The infections were strikingly resistant to massive antibiotic treatment, but complete eradication of infection followed removal of the sutures. The pathogenesis of this type of infection is discussed in relation to sutures as foreign bodies, and preliminary results of experimental studies in dogs using contaminated suture materials of several types were summarized.

REFERENCES

1. Blades, B.: Subphrenic Abscess. Surg., Gynec. & Obst., **103**: 765, 1956.
2. Denton, C., E. G. Pappas, J. F. Uricchio, H. Goldberg and W. Likoff: Bacterial Endocarditis Following Cardiac Surgery. Circulation, **15**: 525, 1957.
3. Eagle, H., R. Fleischman and A. D. Musselman: The Bactericidal Action of Penicillin in Vivo: The Participation of the Host and the Slow Recovery of the Surviving Organisms. Ann. Internal Med., **33**: 544, 1950.
4. Ekstrom, G.: The Surgical Treatment of Patent Ductus Arteriosus. Acta Chirur. Scandinav., Supplement 169, 1952.
5. Elek, S. D.: Experimental Staphylococcal Infections in the Skin of Man. Ann. New York Academy of Sciences, **65**: 85, 1956.
6. Fleming, H. A. and M. E. Seal: Staphylococcal Infection Following Cardiac Surgery. Thorax, **10**: 327, 1955.
7. Howe, C. W.: Prevention and Control of Postoperative Wound Infections Owing to Staphlococcus Aureus. New Eng. J. Med., **255**: 787, 1956.
8. Jones, J. C.: Complications of the Surgery of Patent Ductus Arteriosus. J. Thoracic Surg., **16**: 305, 1947.
9. Scott, H. W.: Surgical Treatment of Patent Ductus Arteriosus in Childhood. Surg. Clinics N. America, **32**: 1299, 1952.
10. Smith, M. R. and W. B. Wood, Jr.: An Experimental Analysis of the Curative Action of Penicillin in Acute Bacterial Infections. III. The Effect of Suppuration upon the Antibacterial Action of the Drug. J. Experimental Med., **103**: 509, 1956.
11. Touroff, A. S. W.: Discussion on "Complications of the Surgery of Patent Ductus Arteriosus" by Dr. John C. Jones and "Complete Division for the Patent Ductus Arteriosus" by Dr. Robert E. Gross. J. Thoracic Surg., **16**: 324, 1947.

DISCUSSION

DR. GERBODE: I couldn't let this moment go by without congratulating Dr. Bahnson on this very excellent paper, and calling attention to this real threat in cardiovascular surgery.

We have had one instance of severe infection following the ligation of a patent ductus arteriosus. Dr. Holman and I operated upon this patient for 7 hours to remove a tiny silk stitch embedded in an aneurysm associated with a recanalized patent ductus. I think this tiny stitch embedded in 4 mm. of granulation tissue had caused a total of about $7,000 worth of hospital care. The day following operation cultures of the blood were sterile, and they remained sterile thereafter. [Applause]

DR. BAHNSON: I can't refrain from expressing my gratitude to Dr. Gerbode for confirming what we suspected from the literature, namely, that such infections are not confined to our hospital.

I was asked over my shoulder what we used to repair the defect in the cases of the aneurysm in the ductuses. At the second operation, the aneurysm was repaired with 6.0 stainless steel wire. In the 2 cases of patent ductus, we closed the aorta in one with stainless steel wire and in the others, closure was with 5.0 arterial silk. [Applause]