of the necrotic septum. Simple suture closure of the epicardial defect as reported by Cobbs and associates or reinforcement of the area with an external patch as advocated by Padro and colleagues might have led to rupture in another area with a fatal result in this case. We achieved long-term patient survival using an aggressive surgical approach that included revascularization, extensive infarctectomy, and replacement of the left ventricular free wall as well as patching of the infarcted perforated septum and plication of the infarcted RV in the repair.

In spite of the patient's extensive infarction and coronary artery disease, successful repair was followed by long-term survival (4 years). Attempts to salvage such critically ill patients seem worthwhile.

References

- Bates RJ, Beutler S, Resnekov L, Anagnostopoulos CE. Cardiac rupture: challenge in diagnosis and management. Am J Cardiol 1977;40:429–37.
- Westaby S, Parry A, Ormerod O, Gooneratne P, Pillai R. Thrombolysis and postinfarction ventricular septal rupture. J Thorac Cardiovasc Surg 1992;104:1506–9.
- Van Tassel RA, Edwards JE. Rupture of heart complicating myocardial infarction: analysis of 40 cases including nine examples of left ventricular false aneurysm. Chest 1972;61: 104–16.
- Edwards BS, Edwards WD, Edwards JE. Ventricular septal rupture complicating acute myocardial infarction: identification of simple and complex types in 53 autopsied hearts. Am J Cardiol 1984;54:1201-5.
- Eisenmann B, Bareiss P, Pacifico AD, et al. Anatomic, clinical and therapeutic features of acute cardiac rupture. J Thorac Cardiovasc Surg 1978;76:78–82.
- Pifarre R, Sullivan HJ, Grieco J, et al. Management of left ventricular rupture complicating myocardial infarction. J Thorac Cardiovasc Surg 1983;86:441–3.
- Cobbs BW, Hatcher CR, Robinson PH. Cardiac rupture: three operations with two long-term survivals. JAMA 1973;223: 532-5.
- 8. Padro JM, Mesa JM, Silvestre J, et al. Subacute cardiac rupture: repair with a sutureless technique. Ann Thorac Surg 1993;55: 20-4.

INVITED COMMENTARY

This case report of "concealed" rupture of the left ventricle by Komeda and Mickleborough is remarkable and of interest to cardiac surgeons for several reasons. First, the imaginative repair used by the authors could not be planned in advance and needed to be created out of "whole cloth" because of the unusual anatomy of the anterior wall and septal defect. Second, the complementary construction of coronary bypass grafts is supported by the patient's excellent long-term survival and is consistent with the advantage in longevity conferred by complementary bypass grafting with other types of mechanical complications of myocardial infarction [1].

The serpiginous nature of the tract within the myocardium probably accounts for the patient's survival and prevention of free rupture into the pericardial cavity. Although I agree that in cases like the one reported by Komeda and Mickleborough there is a definite advantage to having performed preoperative coronary arteriography, many patients with myocardial rupture will not be sufficiently stable hemodynamically to allow this type of angiographic investigation. In such instances, the emergent demands of this myocardial catastrophe must be balanced and take precedence over longer term concerns. It is safe to say, I think, that the majority of patients with myocardial rupture will be treated best by immediate sternotomy, relief of tamponade, and control of the myocardial site of rupture.

Willard M. Daggett, MD

Department of Surgery Massachusetts General Hospital Boston, MA 02114

Reference

1. Muehrcke DD, Daggett WM Jr, Buckley MJ, Akins CW, Hilgenberg AD, Austen WG. Postinfarct ventricular septal defect repair: effect of coronary artery bypass grafting. Ann Thorac Surg 1992;54:876–83.

Fracture of the Internal Lumen of a Datascope Percor Stat-DL Balloon, Resulting in Stroke

Gerard J. Myers, CCP, Roderick W. Landymore, FRCSC, Richard B. Leadon, CCP, and Christina Squires, CPC

Department of Surgery, Dalhousie University, Halifax, Nova Scotia, Canada

Intraaortic balloon counterpulsation was used to wean a 71-year-old man from cardiopulmonary bypass. Thirtysix hours after insertion, the internal lumen of the Datascope balloon fractured, releasing an unknown quantity of helium into the patient's circulation. Leftsided hemiparesis developed, secondary to a right hemispheric infarction.

(Ann Thorac Surg 1994;57:1335-7)

Intraaortic balloon counterpulsation was first used by Kantrowitz and colleagues in 1968 to support a 45year-old woman in cardiogenic shock [1]. Since this original description, the intraaortic balloon has benefited countless patients, and it is now used in more than 70,000 patients annually. The intraaortic balloon, however, has been associated with significant morbidity and mortality [2, 3]. In this report, we describe a patient who suffered an embolic episode that resulted from a spontaneous fracture of the internal lumen of a Datascope Percor DL Balloon

Address reprint requests to Mr Myers, R. C. Dickson Centre, Victoria General Hospital, Room 3065, Halifax, Nova Scotia, Canada B3H 2Y9.

Accepted for publication July 30, 1993.

(Datascope Corp, Paramus, NJ). Fracture of the intraaortic balloon's internal lumen is an extremely rare event.

A 71-year-old man was transferred to the coronary care unit of the Victoria General Hospital on October 8, 1992, with class IV angina. He had previously undergone a five-vessel aortocoronary bypass operation in 1977. Cardiac catheterization demonstrated of impaired left ventricular function, with an ejection fraction of 0.35. The left anterior descending, circumflex, and right coronary arteries were occluded. Coronary circulation was being provided by a vein graft to the left anterior descending coronary artery that had an 85% proximal stenosis.

The patient underwent urgent aortocoronary bypass, and could not be weaned from extracorporeal circulation without the aid of a 40-mL Datascope Percor Stat-DL balloon. The patient was transferred to the intensive care unit, where a chest roentgenogram demonstrated that the balloon was in good position below the left subclavian artery.

Thirty-six hours after operation, his nurse suddenly noted bright red blood backing up inside the gas delivery line connecting the balloon to the balloon console. The gas delivery line was clamped immediately and the balloon was removed. A second balloon (9F; St. Jude Medical, Chelmsford, MA) was inserted, and counterpulsation was resumed because of the patient's unstable status. Although the patient's neurologic status was intact before balloon rupture, 6 hours after the incident the patient was noted to have a left-sided paralysis.

Comment

The intraaortic balloon has been associated with balloon leaks, aortic laceration, bleeding, arterial thrombosis, infection, and neurologic injury [3–8]. The most common complication, however, appears to be related to lower limb ischemia, which occurs in 11% to 18% of patients requiring intraaortic balloon support [3, 4]. Logistic regression analysis indicates that the most important risk factors associated with the use of the intraaortic balloon are diabetes, peripheral vascular disease, and female sex [5].

Tear or perforation of the balloon's polyurethane membrane is an uncommon complication, occurring in only 0.12% to 1.3% of patients [6]. By far the majority of these leaks occur when the balloon comes in contact with calcium deposits in the descending thoracic aorta. Multiple inflations continually expose the balloon to sharp spicules of calcium, which may cause perforation of the polyurethane membrane. Few of these leaks, however, result in death or permanent injury, because the balloon design ensures that the pressure inside the balloon never exceeds the aortic pressure, and because the balloon's emergency mode is designed to create a 100 mm Hg vacuum immediately after sensing a 5-mL gas loss.

The balloon illustrated in Figure 1 was examined by the Health Protection Branch of Health and Welfare Canada. Microscopic examination demonstrated the presence of a complete fracture of the internal lumen 1.9 cm from the tip of the balloon. There were also two other areas of

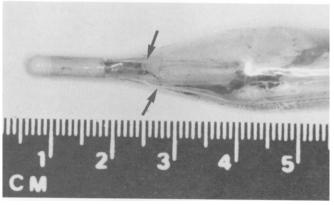


Fig 1. Complete fracture of the internal lumen of a 40-mL Datascope Percor Stat-DL Balloon.

stress fatigue on the internal lumen, located 22.2 cm and 27 cm from the balloon tip.

The presence of a right hemispheric infarction in our patient led to some confusion, because we would have anticipated the helium to embolize up the left carotid artery, resulting in a right-sided hemiparesis, rather than into the innominate artery. Furman and colleagues [7] have explained this anomaly. They simulated intraaortic balloon rupture in dogs by releasing small and large volumes of helium into the descending thoracic aorta. They demonstrated that a 0.5 to 1.0 mL/kg embolus of helium was associated with extensive areas of cerebral artery obstruction, whereas a 1.0 to 3.0 mL/kg embolus resulted in death within 2 to 3 minutes. Furman and colleagues found that helium released into the circulation failed to embolize to anatomically predictable sites. Emboli released into the descending thoracic aorta were found in all four chambers of the heart, throughout the cerebral and coronary circulations, and in the vessels of the abdominal viscera.

Bennett and Elliott [8] indicate that neurologic injuries from gaseous emboli result from more than mere obstruction of the involved artery. The impact of emboli on the cerebral circulation appears to depend upon four factors: (1) Volume of gas released into the aorta is related to the extent of neurologic injury. (2) Tolerance of the brain to ischemia is dependant on the temperature of the patient. (3) Duration of exposure is proportional to the extent of the edema. (4) Pressure of the gas determines the size and amount of bubbles. Embolization of an inert gas may also cause platelet aggregation and protein denaturation, which leads to protein gel formation in areas of low blood flow, further decreasing tissue perfusion and aggravating edema [8]. Hyperbaric therapy may be of benefit in acute helium embolism but, if delayed, may have little impact on the resolution of the neurologic injury [9, 10].

References

 Kantrowitz A, Tjonneland S, Freed P, Phillips S, Butner A, Sherman J. Initial clinical experience with intra-aortic balloon pumping in cardiogenic shock. JAMA 1968;203:135–140.

- Naunheim K, Swartz M, Pennington D, et al. Intra-aortic balloon pumping in patients requiring cardiac operations. J Thorac Cardiovasc Surg 1992;104:1654–61.
- Kantrowitz A, Wasfie T, Freed P, Rubenfire M, Wajszuk W, Schork M. Intra-aortic balloon pumping 1967 through 1982: analysis of complications in 733 patients. Am J Cardiol 1986;57:976–83.
- Lazer J, Ziady G, Dummer S, Thompson M, Ruffner R. Outcome and complications of prolonged intra-aortic balloon counterpulsation in cardiac patients. Am J Cardiol 1992;69: 955–8.
- Funk M, Gleason J, Foell D. Lower limb ischemia related to use of the intra-aortic balloon pump. Heart-Lung 1989;18: 542-52.
- Kayser K, Johnson W, Shore R. Comparison of driving gases for IABPs. Med Instrum 1981;15:51–4.
 Furman S, Vijayaugar R, Rosenbaum R, McMillan M, Esher
- Furman S, Vijayaugar R, Rosenbaum R, McMillan M, Esher D. Lethal sequelae of intra-aortic balloon rupture. Surgery 1971;69:121–9.
- Bennett PB, Elliot DH. The physiology and medicine of diving. 3rd ed. Bailliere Tindal, London: 1982:435–60.
- Fredericksen J, Smith J, Brown P, Zinetti C. Arterial helium embolism from a ruptured intra-aortic balloon. Ann Thorac Surg 1988;46:690–2.
- Murphy B, Harford F, Cramer F. Cerebral air embolism resulting from invasive medical procedures. Treatment with hyperbaric oxygen. Ann Surg 1985;201:242–5.

Late Esophageal Fistula After Pneumonectomy

Jibah Eng, FRCS, Sabaratnam Sabanathan, FRCS, and Alan J. Mearns, FRCS

Department of Thoracic Surgery, Bradford Royal Infirmary, Bradford, England

Esophageal fistula formation after pulmonary resection is rare. We present a case of esophagocutaneous fistula 9 years after left pneumonectomy for squamous cell carcinoma of the bronchus. This was confirmed on barium swallow and endoscopy. The fistula was sealed successfully with monomeric *n*-butyl-2-cyanoacrylate tissue adhesive. The simplicity and effectiveness of this method of management is discussed and the multitude of surgical options considered.

(Ann Thorac Surg 1994;57:1337-8)

Postpneumonectomy esophageal fistulas are rare, with an incidence of 0.5% [1, 2]. The majority were reported in tuberculosis or suppurative pulmonary disease [1]. The management of such cases is complicated, involving multiple procedures, with varying degrees of success. In many cases, the perilous condition of these patients may complicate their postoperative course [3]. With these considerations, we present our recent experience in managing a patient with late esophagocutaneous fistula, successfully treated with tissue adhesive. A 45-year-old man underwent left pneumonectomy for a T2 N0 M0 poorly differentiated squamous cell carcinoma of the left main bronchus. An infection of the postpneumonectomy space became apparent 3 months later. Rib resection and open drainage of the empyema were performed, followed by an eight-rib thoracoplasty (ribs 2 to 9) 9 months later. He made a good postoperative recovery. Unfortunately, a discharging sinus persisted, for which a Clagget window was performed subsequently.

Nine years after his original pneumonectony, the patient noticed food particles discharging through his Clagget window. Barium swallow confirmed the esophagocutaneous fistula (Fig 1). On rigid esophagoscopy, the fistula opening was seen in the middle esophagus. An 18-gauge central venous catheter was inserted via the cutaneous opening. Its position was confirmed under image intensifier and by injection of methylene blue. Tissue adhesive (5 mL of monomeric n-butyl-2-cyanoacrylate; Histoacryl blue, B. Braun, Germany) was injected into the fistula tract while the cannula was withdrawn. The tissue adhesive was seen both inside the esophagus and at the cutaneous opening. This resulted in immediate cessation of discharge from the fistula. A repeat barium swallow (Fig 2) showed no further evidence of fistula 18 months later. The patient remained well with no further discharge.

Comment

Postpneumonectomy esophageal fistulas occur mainly on the right side, due to close proximity to the pleura on the right [1]. Malignant fistula may be present at the time of the original diagnosis of malignancy. Frequently the fistulas occur after radiotherapy for inoperable or recurrent disease. In late fistulas, the possibility of tumor recurrence must be considered [2]. There was no evidence of recurrent tumor in the patient reported here, as confirmed on esophagoscopic biopsy.



Fig 1. Barium swallow showing esophagocutaneous fistula (arrow).

Accepted for publication July 31, 1993.

Address reprint requests to Mr Sabanathan, Department of Thoracic Surgery, Bradford Royal Infirmary, Duckworth Lane, Bradford, West Yorkshire, BD9 6RJ, England.