UNILATERAL PULMONARY OEDEMA FOLLOWING AORTA TO RIGHT PULMONARY ARTERY ANASTOMOSIS
(WATERSTON'S OPERATION)

Case Report

M. R. SALEM, K. Z. MASUD, C. J. TATOOLES AND H. O. YANES

SUMMARY

Unilateral pulmonary oedema may occur following anastomosis of the ascending aorta to the right pulmonary artery. The oedema is probably related to selective perfusion of the right lung due to a large shunt or kinking of the right pulmonary artery. Anaesthetists must be aware of this complication so that treatment may be instituted early. It is suggested that if severe unilateral pulmonary oedema occurs early in the postoperative period, re-operation should be undertaken to decrease the size of the shunt or relieve an obstruction.

Anastomosis of the ascending aorta to the right pulmonary artery (Waterston's shunt) has been performed recently in preference to other procedures in patients with severe heart disease, due to diminished pulmonary blood flow (Waterston, 1962; Yacoub, Somerville and Ross, 1968; Somerville et al., 1969). Although the success of the Waterston operation is well established, certain postoperative complications may occur, including heart failure (Yacoub, Somerville and Ross, 1968), unilateral pulmonary oedema (Yacoub, Somerville and Ross, 1968; Somerville et al., 1969) and pericardial effusion with tamponade (Radley-Smith, Gonzalez-Lavin and Somerville, 1970).

The following case report describes the development of severe unilateral pulmonary oedema following this procedure.

CASE REPORT

A 64-month-old female infant was admitted to the hospital because of increasing dyspnoea and cyanosis. On physical examination, a grade VI systolic murmur was heard at the mid-left sternal border. A chest radiograph showed a normal heart size and diminished pulmonary vascularity (fig. 1). Electrocardiography revealed right atrial and ventricular hypertrophy. During cardiac catheterization the pressures in the ascending aorta and the main pulmonary artery were 70/40 and 16/8 mm Hg respectively. The oxygen saturation of blood in the aorta was 64.8 per cent, and 43 per cent in the main pulmonary artery. The cineangiogram demonstrated the presence of infundibular stenosis and trabecular hypertrophy of the right ventricle. The diagnosis of Tetralogy of Fallot was made and the patient was scheduled for performance of the Waterston shunt operation.

Anaesthesia was induced and maintained with halothane, nitrous oxide, and oxygen. A total dose of 2 mg of tubocurarine was injected during an uneventful 2-hour operation. A right thoracotomy was performed at the point of intersection of the right pulmonary artery and the ascending aorta. An anastomosis, 3.5 mm internal diameter, was constructed and the pericardium was opened just over the aorta. An anastomosis, 3.5 mm internal diameter, was constructed at the point of intersection of the right pulmonary artery and the ascending aorta. After the shunt had been completed, cyanosis disappeared. At the termina-

Fig. 1
Pre-operative chest film showing diminished pulmonary vascular markings, particularly on the right side.

MOHAMED R. SALEM, M.D., KHAN Z. MASUD, M.D. (Division of Anesthesiology); CONSTANTINE J. TATOOLES, M.D., HECTOR O. YANES, M.D. (Division of Cardiothoracic Surgery); Cook County Hospital, 1825 West Harrison Street, Chicago, Illinois 60612.
tion of the procedure, the effect of tubocurarine was reversed by injection of a standard mixture of atropine and neostigmine. The patient was extubated and allowed to breathe spontaneously in a tent with 40 per cent oxygen and humidification. Vital signs were stable, and an immediate postoperative chest film showed an increase in pulmonary vascular markings; they were more evident on the right side than on the left.

Next morning the patient became dyspnoeic and cyanotic, but there was no alteration in central venous pressure. A chest radiograph showed generalized haziness over the right lung field. The patient was reintubated and ventilation was controlled by means of a volume preset ventilator and an inspired oxygen concentration of 50 per cent. Arterial blood-gas analysis revealed: PaO₂ 31 mm Hg; PaCO₂ 20 mm Hg; pH 7.58. The inspired oxygen concentration was increased to 80 per cent, but there was no alteration in PaO₂, and the patient was given digoxin 0.1 mg, and frusemide 10 mg intravenously. No significant increase in urinary output followed. A positive pressure of 5 cm H₂O was then applied to the expiratory limb of the ventilator. A subsequent chest film showed that the heart size was normal, that there were increased pulmonary vascular markings in both sides, a generalized haziness in the right lung field and a small pneumothorax in the left side above the diaphragm (fig. 2).

One hour after institution of continuous positive pressure ventilation, a fall in blood pressure and pulse rate was noted. The end-expiratory positive pressure was discontinued immediately, but the peripheral pulse disappeared and the blood pressure could not be measured. Another chest film at this time revealed an increased size of the pneumothorax. An emergency left thoracotomy was performed. Several large bullae were seen and air was seen to be bubbling out. Internal cardiac massage was continued, but all resuscitative measures were unsuccessful. Autopsy findings were: right pulmonary oedema, hyaline membrane formation in both lower lungs, left haemothorax with 50 ml of blood and a shunt between the right pulmonary artery and aorta of 4 mm in diameter.

**DISCUSSION**

This case clearly demonstrates the development of unilateral pulmonary oedema following Waterston's operation. Other factors that could have resulted in pulmonary oedema, such as aspiration of gastric contents, were easily excluded. The pulmonary oedema was not accompanied by heart failure, since the heart size and central venous pressure remained the same throughout the postoperative course.

Systemic-pulmonary artery anastomosis is especially indicated for patients with cyanotic heart disease who are too small or have a condition too complex for total correction. Various types of systemic-pulmonary artery shunts have been described, but all seem to have some disadvantages. Following Blalock's operation (left subclavian-pulmonary artery anastomosis) (Blalock and Taussig, 1945), there is a significant incidence of spontaneous closure and the size of the shunt may not be adequate in infants (Yacoub, Somerville and Ross, 1968; Somerville et al., 1969). Potts' anastomosis (left pulmonary artery—descending aorta) (Potts, Smith and Gibson, 1946) may not be satisfactory in patients with right-sided aortic arch, and difficulties in closing the shunt are frequently encountered at the time of total correction (Yacoub, Somerville and Ross, 1968; Somerville et al., 1969).

The advantages of Waterston's operation include the simplicity of the procedure and the high success rate, even in infants with small vessels, and in the presence of a right aortic arch (Yacoub, Somerville and Ross, 1968; Somerville et al., 1969; Cooley and Hallman, 1966). Nevertheless, the operation carries some risk. Selective perfusion of part or the whole right lung may result if the shunt is too large or if there is kinking of the right pulmonary artery (Somerville et al., 1969). Although there is a tendency for all types of anastomotic operations to produce preferential perfusion of the ipsilateral lung (Somerville et al., 1969), the incidence of unilateral pulmonary oedema seems to be high following Waterston's shunt.
The stoma size should be planned according to the size of the patient and type of congenital disease, and in infants an anastomosis of 2-3 mm is sufficient (Somerville et al., 1969). These authors state that kinking of the right pulmonary artery may be avoided by making the anastomosis as far posterior on the aorta as possible, working from behind the mobilized superior vena cava. They have suggested that unilateral pulmonary oedema may also be related to some narrowing in the proximal pulmonary arteries and the sudden change to vigorous pulsatile flow in the pulmonary vessels.

Measures needed in the management of unilateral pulmonary oedema following Waterston's shunt include artificial ventilation with high inspired oxygen concentration and administration of diuretics and digitalis. If it is associated with pleural effusion, paracentesis may be required. If the shunt is too large or if there is obstruction to one of the pulmonary arteries, surgical correction may be advisable. Somerville and associates (1969) have reported that 9 of 30 patients developed unilateral pulmonary oedema following Waterston's operation. This cleared after 3-5 weeks of medical treatment. One patient, however, required removal of an obstruction from the left pulmonary artery and this was followed by dramatic improvement of the pulmonary oedema.

The use of continuous positive pressure ventilation has been shown to be of significant value in raising the arterial oxygen tension in certain pulmonary conditions, including pulmonary oedema (Kumar et al., 1970). Unfortunately, in our patient, its use was complicated by the presence of pneumothorax in the left side. The left lung, being more compliant than the right, became overinflated. The presence of bullae is an important contributing factor in the development of pneumothorax. The incidence of pneumothorax is surprisingly high in patients in whom continuous positive pressure has been used (Kumar et al., 1970). However, this does not seem to be related to the positive pressure, but rather to the condition of the patient's lungs (Holaday, 1970, personal communication).

Anaesthetists must be aware of the possibility that unilateral pulmonary oedema may be a complication of Waterston's operation. Early recognition and management is of vital importance. This cause must be differentiated from other causes of pulmonary oedema. It is suggested that if unilateral oedema occurs early in the postoperative period, re-operation should be undertaken to decrease the size of the shunt or relieve an existing obstruction.

REFERENCES


OEDEME PULMONAIRE UNILATERAL APRES ANASTOMOSE ENTRE L'AORTE ET L'ARTERE PULMONAIRE DROITE (MALADIE DE WATERSTON)

SOMMAIRE
Un oedème pulmonaire unilatéral peut survenir après une anastomose entre l'aorte ascendante et l'artère pulmonaire droite. L'oedème est probablement en relation avec la perfusion sélective du poumon droit, due à un grand shunt ou à un tortillement de l'artère pulmonaire droite. Les anesthésistes doivent être au courant de cette complication afin d'en permettre le traitement précoce. Les auteurs suggèrent en cas d'oedème pulmonaire unilatéral sévère, tôt dans la période postopératoire, de réopérer pour diminuer la taille du shunt ou éliminer l'obstruction.
EINSEITIGES LUNGENÖDEM AUFGRUND EINER ANASTOMOSE ZWISCHEN AORTA UND RECHTER PULMONALARTERIE (WATERSTON’SCHER KRANKHEIT)

ZUSAMMENFASSUNG

Bei einer Anastomose zwischen aufsteigender Aorta und rechter Pulmonalarterie kann es zu einem einseitigen Lungenödem kommen. Das Ödem entsteht wahrscheinlich durch eine selektive Perfusion der rechten Lunge infolge des großen Shunts zu den rechten Arterien. Der Anaesthesist muss diese Komplikation kennen, damit rechtzeitig die Therapie einsetzen kann. Es wird vorgeschlagen, bei Auftreten eines schweren einseitigen Lungenödems in der frühen postoperativen Phase eine Re-Operation durchzuführen und die Shuntgröße zu verringern oder eine Obstruktion zu beseitigen.

CORRESPONDENCE

Sir,—The report by Clark and Cockburn (1971) of anaphylactoid response to repeated administrations of thiopentone which occurred in a case of irradiated bladder malignancy brings up the question as to whether it is the condition of the patient per se rather than the drug that caused the reaction. From the literature it certainly appears that pelvic cancers are more sensitive than others to repeated exposures of at least three anaesthetic agents. Thiopentone caused a reaction not only in Clark and Cockburn's patient but also in two other patients with bladder malignancies reported by Currie et al. (1966) and Anderton and Hopton (1968). Propanidid caused severe reactions in three patients with irradiated uterine cancers reported by us (Stovner and Endresen, 1971). Similar cases were also reported by Manz and Fank (1969), who take the view that the irradiation is the main precipitating factor.

Administration of halothane to pelvic cancers has caused a strikingly high incidence of severe and often fatal jaundice. The incidence is far higher than can be expected from repeated administrations alone. The first case was reported as long ago as 1963 by Beddard and since then other workers have reported similar cases (Ashton, O'Connor and Williams, 1963; Chambers, Sewell and Young, 1964; Riviera, 1970). Large series of several thousand patients who have received halothane for radiation implantation in a cancerous uterus have recently been reported from Denmark (Nielsen and Dalsgaard, 1970) as well as from Australia (Hughes and Powell, 1970). The jaundice, often fatal, occurred with a frequency of about 1 per cent in both series. Pelvic malignancy, in most cases treated by irradiation, is a common denominator in all these cases.

J. STOVNER
R. ENDRESEN
Oslo

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