INJURIES OF THE CHEST*

A. E. WILKINSON, F.R.C.S. (EDIN.), F.R.C.S. (GLASG.), *Department of Surgery, University of the Witwatersrand, and Accident Service, Johannesburg Hospital, Johannesburg*

Chest injuries range in severity from minor trauma requiring no treatment, to the most serious of injuries. Their assessment and management may require a nicety of both surgical and medical treatment, and may tax clinical, nursing and laboratory services to their utmost.

CLINICAL MATERIAL

This series is a retrospective study of all patients with chest injuries who were admitted to the Accident Service of Johannesburg Hospital during the period 1 November 1963—1 May 1968, i.e. 4½ years.

Table I represents a detailed breakdown of all the cases seen during the 4½-year period.

TABLE I. CHEST INJURIES, 1963 - 1968

Type of injury	*No. of patients*	*Stay in hospital (days)*	*Deaths*
Contusions of the chest (no fractures, no other injuries)	31	3·5	0
Fractured ribs (no complications)	40	4·7	0
Fractured ribs and pneumothorax	20	8	0
Fractured ribs and haemothorax	26	11	0
Fractured ribs and pneumonia	14	10	1
Tension pneumothorax	6	13	0
Bilateral pneumothorax	4	5·5	0
Fractured ribs with concussion	54	6	0
Fractured ribs and severe brain injuries	7	21	2
Fractured ribs, concussion and miscellaneous fractures	25	12	0
Fractured ribs and miscellaneous injuries	21	15·6	0
Fractured sternum	11	11	0
Stabbed chest and pneumothorax	5	34	0
Stabbed chest and haemothorax	20	9·5	0
Bullet wound of the chest	12	22	1
Ruptured bronchus	2	1	2
Mediastinal haematoma	4	7	3
Ruptured diaphragm	8	22	2
Flail chest	52	26·6	16
Totals	362	12·8	27

Contusions of the Chest

There were patients with severe contusions of the chest but in whom no fractures were seen on X-ray examination. Of this group of 31 patients, 6 were admitted as possible myocardial contusions. Four subsequently showed ECG changes, which included inverted T waves, ventricular extrasystoles and ischaemic changes. Three patients developed a pneumothorax after admission. This was thought to be due to bursting of a bulla on the surface of the lung at the time of the impact.

There were 2 patients with contusions of the lung and haemoptysis. Three patients were admitted for observation for possible rupture of an abdominal viscus, in addition to chest injury. Eight patients had multiple contusions.

Our experience shows that even in the absence of fractures, patients with severe chest contusions merit admission to hospital for observation and investigation. An electrocardiogram should be done as a routine, and where pain does not diminish, further chest X-rays should be taken in view of the late development of pneumothorax.

Fractured Ribs

Ribs may have a single or a double fracture. The latter will be considered later.

There were 154 patients with single fractures of the ribs. These resulted from car accidents in ⅔ of the cases, falls in ⅛, and assaults in ⅛. The 5th - 9th ribs inclusive were the most commonly fractured. Thirty-six patients were admitted with fractures of the ribs only, with no other injuries, and 58 patients were admitted with fractured ribs without complications but with other injuries. When pain was severe, these patients were treated with nerve block, 2 ml. of 2% lignocaine being injected round each intercostal nerve in succession, beginning with the 2 intercostal nerves above the first fractured rib, and ending 2 intercostal spaces below the last fractured rib. This produced considerable relief of pain, with improvement of breathing and of the ability to expectorate. Nerve block was repeated as required.

Non-cough-depressant sedation, breathing exercises and early ambulation were useful. All patients were treated without strapping of the chest. Some of these patients were treated with an intravenous Xylocaine drip—40 ml. 2% Xylocaine added to 1,000 ml. 5% dextrose water—and this was given over a 12 - 24-hour period. This produced considerable relief of pain and improvement of breathing in many patients.

The stay in hospital was prolonged by the development of pneumonia or if many ribs had been fractured or if social circumstances dictated, e.g. an elderly person, living alone, who arrived at hospital with fractured ribs would be hospitalized for a longer period.

Fractured Ribs and Pneumothorax

There were 20 patients in this group. The average number of ribs fractured was 3. These were usually caused by a fairly severe form of injury, such as a car accident or a kick in the chest. Those patients in whom the extent of the pneumothorax was more than 20% were treated by an intercostal catheter in the second interspace anteriorly, and underwater seal drainage.[1] Insertion of the catheter, using a wide-bore trocar and cannula, was done in the operating theatre. No drain was used in 8 patients. It is important to get the lung re-expanded quickly, otherwise atelectasis and pulmonary infection may occur. The use of a low-pressure suction pump (negative pressure 3 lb./sq.in.) attached to the 'free' side of the underwater seal achieved full expansion of the lung within 1 - 6 hours.

All patients were given breathing exercises. The drainage tube was clamped for some hours before removal, to check that the air leak had sealed before final removal of the tube.

Pulmonary infections also occurred in 5 patients, one

*Date received: 24 December 1968.

of whom died. There were no other deaths in this group. All patients were given physiotherapy.

Fractured Ribs and Haemothorax

There were 26 patients in this group. All had several ribs fractured, the average number being 4. These patients were treated by intercostal drainage in the 7th interspace in the mid-axillary line, and using an underwater seal, if the extent of the haemothorax was greater than 20%. The drain was removed within 48 hours in the majority of patients, as the incidence of infection rises rapidly after that period. One of these patients developed a clotted haemothorax and required thoracotomy and decortication. One developed pneumonia. Intercostal nerve block, physiotherapy, blood replacement, aspiration of the chest and antibiotics were used as required. There were no deaths in this group.

Rigidity of the abdominal muscles in the hypochondrium on the same side as the fractured ribs occurred in some of these patients. Absence of intra-abdominal injury was diagnosed by reduction of the rigidity after treatment of the haemothorax, by the presence of bowel sounds, absence of spreading abdominal pain and by negative abdominal paracentesis. A check X-ray chest examination was made in all these patients, 2 or 3 hours after admission, as we regard every acute haemothorax as being progressive until proved otherwise.

Fractured Ribs and Pneumonia

This group constituted a distinct clinical entity. There were 14 patients, whose average age was 56 years. All these patients had delayed in coming to hospital after injury, so that there was delay in starting treatment. The average delay was 3½ days. Many middle-aged people do not have a good respiratory reserve, and when chest movement is reduced by the pain of fractured ribs, or by strapping the chest, as with 2 of the patients, atelectasis and pneumonia are apt to result. Our patients were treated with antibiotics, repeated intercostal nerve blocks, physiotherapy, inhalations and non-cough-depressant sedation. There was one death, which was due to pulmonary embolism.

Tension Pneumothorax

These presented with considerable dyspnoea, which rapidly became worse. There was restricted movement of one side of the chest, with poor air entry, fast, shallow breathing and tachycardia. There were 9 such patients. In 4 patients fractured ribs were present, and stab wounds accounted for 2 cases. There were also 2 patients with rupture of the bronchus, both of whom died (see later), and one patient with a flail chest (see later).

The average duration of hospitalization of these 6 patients was 13 days, the time being prolonged in one patient by chronic obstructive airways disease (15 days), and by a haemothorax and persistent pleural effusion in one (23 days).

Emergency treatment was performed in the Accident Service Resuscitation Room by inserting a wide-bore needle into the affected side of the chest and allowing escape of excess air. This was followed by an intercostal catheter in the second space anteriorly and underwater seal drainage.

Bilateral Pneumothorax

There were 4 patients in this group, 3 due to stab wounds and one due to fractured ribs. Two patients required bilateral, intercostal tube drainage and underwater seal drainage. One patient had widespread abdominal rigidity and underwent laparotomy after insertion of an intercostal tube with underwater seal drainage. Apart from contusion of bowel, no visceral injury was found. There were no deaths.

Fractured Ribs and Brain Injuries

In 86 out of 182 patients with fractured ribs, head injuries were also present, i.e. in almost 50%. Of these, 54 suffered from fractured ribs and concussion. The average hospitalization for these patients was 6 days, the length of time being dependent on the extent of the injury to the ribs. Twenty-five patients had fractured ribs, miscellaneous fractures and concussion. There were no deaths in these two groups, but 8 patients were admitted in coma with severe contusions of the brain and fractured ribs. They also had other injuries, such as limb fractures, which were not lethal. Of these 8 patients, 3 died. This section excludes the patients with flail chests.

The above is in keeping with the findings of other clinicians. Schrire[2] pointed out that when chest injury accompanied a significant head injury, the mortality rate was 31% as compared with 9% for head injuries alone.

Fractured Ribs and Miscellaneous Injuries

These injuries included 12 patients with ruptured spleens, and also patients with fracture of the spine and clavicle, but brain injuries are excluded. There were 21 patients in this group and one death.

Fractures of the Ribs (not flail chest)

Table II gives a summary of the above detailed analysis of the various complications.

TABLE II. CONCOMITANT INJURIES

Type of injury	*No. of patients*	*Deaths*
No complications, no other injuries	36	0
Fractured ribs and unassociated injuries	58	0
With pneumothorax	15	0
With pneumothorax and pulmonary infections	5	1
With haemothorax	24	0
With haemothorax and clotted haemothorax	1	0
With haemothorax and pneumonia	1	0
With pneumonia	14	1
	154	2

Fractured Sternum

There were 11 patients with fracture of the sternum. All were due to steering-wheel injuries and failure to use seat belts, except in one case resulting from a fall. Marked tenderness was present over the sternum in all these patients. In two cases there was some depression of the fractured segment distally, and in two patients the right 5th and 6th ribs were fractured. Two patients had myocardial contusions diagnosed on the ECG.

Stabbed Chest and Pneumothorax

There were 34 patients in this group, with an average stay in hospital of 5 days. Pneumothoraces of 20% in size were treated by intercostal drainage and an under-

water seal. One patient developed basal pneumonia. There were no cases of empyema and there were no deaths in this group. One patient also had a wound of the stomach, for which a laparotomy was performed. Ten of these 34 patients were intoxicated on arrival!

Stabbed Chest and Haemothorax

There were 20 patients in this group, with an average stay of 9·5 days in hospital. Intercostal drainage was used for haemothoraces greater than 20% in size. These were present in 9 patients. In contrast to haemothoraces caused by rib fractures, 6 of these patients lost more than a litre of blood into the pleural cavity and required blood replacement. Aspiration of the chest was used in 4 cases, and 3 patients with minimal haemothoraces were treated conservatively. Antibiotics and physiotherapy were used for all patients. Two patients developed clotted haemothoraces. The blood clot was removed at thoracotomy by a thoracic surgeon. There were no deaths.

Bullet Wounds of the Chest

In 6 out of a total of 12 patients the bullet wounds of the chest were self-inflicted, 3 were victims of assaults, 2 patients had been shot by police and one had been shot accidentally.

All these patients developed a haematoma of the lung along the track of the bullet and a haemothorax. Eight patients required an intercostal drain for the haemothorax, 2 developed pneumonia, and one developed empyema. Four patients required laparotomy for bullet wounds of the stomach and intestines. One of these patients died during operation from a wound of the aorta. The average duration of hospitalization was 22 days for the 12 patients. One patient, however, who was shot through the chest and stomach, subsequently developed peritonitis, a pelvic abscess, intestinal obstruction and empyema thoracis. His stay in hospital was 156 days. Omitting this patient, the average stay in hospital was 10 days.

Ruptured Bronchus

There were 2 patients, one of whom survived for only half an hour after arrival at hospital.

The second patient, a man aged 25 years, was thrown off his motor cycle and his chest hit the kerb. He presented with marked dyspnoea, a respiratory rate of 40/min. and a tension pneumothorax. A thoracic surgeon performed bronchoscopy, drainage was established, tracheostomy was performed, and he was put on an Engström respirator. A second and then a third intercostal catheter were required simultaneously to reduce the pneumothorax. A thoracic surgeon performed bronchoscopy, but was unable to see a tear in the trachea or the bronchi, and so advised against thoracotomy. Postmortem examination showed rupture of the right main bronchus.

Rupture of a bronchus should be suspected whenever a large volume of air escapes continuously from one or more intercostal catheters draining a tension pneumothorax. This in itself may be an adequate indication for urgent thoracotomy, even in the presence of negative bronchoscopy. Our experience shows that bronchoscopy may be an unreliable method of diagnosis.

Mediastinal Haematoma

Mediastinal haematoma may follow an injury to the chest such as that incurred in a motorcar accident; a fall from a height, onto the chest; a crush injury; or a penetrating injury.

The bleeding in the mediastinal haematoma may come from a rupture of the aorta or its branches, from torn mediastinal veins or from the marrow of a fractured sternum or vertebrae. Venous bleeding occurs at low pressure, and does not displace the mediastinal structures, such as the trachea. Arterial bleeding results in a large mediastinal haematoma, often displacing the oesophagus and the trachea. Rupture of the thoracic aorta is caused by sudden deceleration of the thorax, e.g. when a car at high speed is brought to a sudden and complete stop. The aortic arch is fixed by its branches, but the less securely fixed parts, such as the descending part of the arch, move forward. Tearing of the aorta occurs commonly just distal to the region of the subclavian artery. In those who do not die immediately, rupture into the mediastinum occurs within a few hours in most cases. Symptoms are inconstant. There may be chest pain, similar to that of coronary thrombosis, if rupture causes coronary ischaemia. Dyspnoea and dysphagia may result from pressure in the mediastinum. Hypertension has been recorded. A systolic murmur is occasionally heard. Paraplegia may result from interference with the blood supply to the spinal cord. The only reliable sign is a widening of the mediastinum as seen on X-ray examination. This should be followed by aortography to localize the site of the tear, and exploration without delay.

There were 4 patients with mediastinal haematomata, with 3 deaths.

Traumatic Rupture of the Diaphragm

This may occur due to open injury (stabs, bullet wounds, operations) or due to closed injuries (crush injuries of the chest). Rarely, it may follow subdiaphragmatic sepsis. Des Forges[3] has stated that any type of blunt thoracic or abdominal trauma may give rise to diaphragmatic rupture. Forces applied to the anterior abdominal wall and flanks are transmitted equally in all directions, and, because the diaphragm offers the least resistance, it is ruptured. The liver protects the right half of the diaphragm which is seldom ruptured. In most series, rupture of the left half is 20 times more common than rupture of the right half.

Once rupture has occurred, the negative pressure in the thoracic cavity sucks the abdominal organs up. The omentum protrudes through the tear in the muscle fibres and prevents healing. The stomach and colon enter the left chest most commonly, and small bowel not uncommonly. The spleen, tail of the pancreas, left adrenal gland and left kidney have all been found in the left chest on occasion.

There were 8 patients with rupture of the diaphragm. Two were due to stabs and one was due to a bullet wound. In 4 patients rupture followed blunt trauma: three were due to car accidents, and one was due to a crush injury. One case followed sepsis (see later).

Carter *et al.*[4] divide diaphragmatic hernia into three phases, viz. the acute phase, the interval phase, and the phase of obstruction with strangulation. In the acute phase (i.e. immediately after the accident) the patient is in a state of shock and often has other injuries, which

may disguise the diaphragmatic injury. There is severe upper abdominal pain, usually in the left upper quadrant. Dyspnoea and cyanosis are common. Fractures of the ribs may, or may not, be present. There may be dullness, or tympany, on percussion of the left lower chest. The mediastinum and trachea may be shifted to the right in left-sided hernia. On auscultation, peristaltic sounds may be heard in the left chest. X-ray examination should be made with the patient in the erect posture and in the Trendelenburg position.

Commonly the appearance is that of high elevation of the left dome of the diaphragm with a fluid level situated in an area normally well within the pleural cavity. It is the wall of the stomach which gives the initial impression of being an elevated diaphragm. The presence of the stomach in the thorax may be verified by passing a nasogastric tube and by injecting contrast medium and taking further X-rays in the Trendelenburg position. The X-ray appearance varies, and barium may pass into and out of the stomach with no obstruction. If there is a distal obstruction or a proximal obstruction the picture varies accordingly.

Other radiological aids include repeat serial X-rays of the chest which may show a progressively enlarging shadow of the stomach in the left chest.

Screening of the diaphragm may show paradoxical movement of the upper border of the abdominal viscera. Schwindt and Gale[5] recommend diagnostic pneumoperitoneum, 500 ml. of air being put into the peritoneal cavity, which becomes visible in the chest on X-ray in the erect posture. In the interval phase, a barium enema may be useful.

In the acute phase, the indications for immediate operation are the presence of an intra-abdominal haemorrhage, strangulation of viscera, and perforation of organs.

There were 2 male patients with stab wounds of the diaphragm, and one female with a bullet wound of the diaphragm, which were sutured at laparotomy.

There was one male patient with ruptured diaphragm, spleen and liver. Splenectomy was performed and the diaphragm and the liver were sutured. He also had a severe brain-stem injury and died, his death being the second in this group.

The average stay in hospital was 22 days, the time being prolonged by treatment of accompanying injuries.

Flail Chest

A 'flail' chest or 'stove-in' chest results from a severe crushing injury, with fracture of a number of ribs in two places each, creating instability of that part of the chest wall between the fractures, shown clinically by paradoxical respiration.

There were 52 patients with this injury in our series (36 males, 16 females). In 49 patients the injuries resulted from car accidents, one patient suffered a crushing injury when his motor-scooter fell on him, and one was run over by a farm tractor. One injury was due to a motorcycle accident.

The unstable area was situated laterally in 32 patients, anteriorly in 12 patients and posteriorly in one; the site was not recorded in 7 cases. The anterior segment may be formed by fractures of the costal cartilages as well as fracture of the ribs. A small flail area may not interfere with respiration to a significant extent, but a large area causes respiratory failure. The work of Maloney *et al.*[6] showed that when part of the chest wall becomes flail, the negative pressure which the patient can produce in the affected pleural cavity is diminished. The reduction of negative pressure may be such that the patient is unable to produce adequate pulmonary ventilation. This, in turn, causes decreased oxygen tension in the arterial blood and an accumulation of carbon dioxide, and so respiratory failure results. The patient is unable to cough effectively, causing retention of secretions, atelectasis, and pulmonary infections.

The mediastinum may also move to and fro if this paradoxical respiration is sufficiently severe, and this affects the action of the heart. When the negative pressure in the thorax is lowered, the return of venous blood to the heart is diminished and diastolic filling is reduced. The cardiac output becomes smaller and tachycardia and shock supervene. As Van Hasselt and Marchand[7] have pointed out, a chain of greater respiratory effort, more paradoxical breathing, pain, shock and exhaustion develops.

In 5 of these 52 patients, paradoxical respiration did not occur as long as the trachea, bronchi and bronchioles remained fully opened. However, after 2 or 3 days, there was some retention of secretions in these patients, in spite of vigorous physiotherapy. Partial obstruction to the air passages caused increased respiratory effort, and paradoxical respiration then occurred. It was noted in 4 cases that a spreading contusion of the lung produced a similar effect.

All our patients complained of severe pain in the chest and were dyspnoeic. Forty-one patients presented with signs of respiratory failure.

Injury to the chest wall alone is relatively uncommon. Thirty-three of our patients had accompanying intrathoracic injuries. Pneumothorax occurred in 14 patients, being of the tension type in 3 patients. Haemothorax was present in 20 patients, and required intercostal drainage in 8 cases. Bronchospasm requiring treatment occurred in 7 patients. Evidence of myocardial contusion was sought by routine ECG examination and was present in 4 patients. Rupture of the left diaphragm occurred in 2 patients.

Non-thoracic injuries are not infrequently present in patients with flail chest. Of the 52 patients in this series, 33 patients had other injuries. Splenectomy was required in 2 patients and rupture of the liver was a concomitant injury in 2 patients. Rupture of the urinary bladder occurred in 2 cases. Limb fractures were present in 12 cases, fractured pelvis in 8 patients, and fractured clavicles in 10 patients.

Abdominal distension requiring nasogastric suction occurred in the acute phase in 6 patients.

Bronchopneumonia may follow contusion of the lung or atelectasis, and this occurred in 12 cases. Acute tubular necrosis was evident in 2 patients within a few days of the injury.

Radiological examination of the chest is urgent, and was carried out immediately after treatment for shock

had begun, or after such emergencies as tension pneumothorax had received attention. PA and lateral films were obtained in the erect posture, whenever possible, and these films were repeated frequently to assess progress. Radiological evidence of increasing pneumothorax or haemothorax, rupture of the left diaphragm, widening of the mediastinum or mediastinal emphysema was sought.

In all patients with respiratory distress, blood samples were sent for estimation of pH, PCO_2, haemoglobin and electrolyte values.

Treatment depended primarily on whether respiratory failure was present or not, and, if present, on its extent. These patients thus fell into 3 therapeutic categories as follows: In the first group, numbering 8 patients, respiratory failure was not present. They were treated by intercostal nerve block, non-cough-depressant sedation and physiotherapy.

The second group, comprising 2 patients, were those in mild respiratory failure, in whom the blood-gas values were not markedly distorted. In these, treatment consisted of clearing the airways of secretions and blood by suction, giving oxygen and treating shock caused by other injuries. Tracheostomy performed under local anaesthesia proved to be adequate treatment by reducing the 'dead air' space in the air passages.

The third group of patients, numbering 37, were those who arrived at hospital in severe respiratory failure. Many of these patients had suffered severe brain injuries, and four had fractures of the base of the skull. Ten of these patients were in coma. Treatment consisted of clearing the mouth, pharynx and tracheal secretions by suction, and of giving oxygen. An emergency tracheostomy was performed under local anaesthesia, and then a Bird respirator (8 patients), or for the worst cases an Engström respirator (29 patients), was put into use. In some patients an endotracheal tube was first passed, and the patient was 'pumped' with an 'Ambu' bag and oxygen, while tracheostomy was being performed. Where a pneumothorax was present, this was treated by an intercostal catheter and underwater drainage, before the respirator was used.

In urgent cases, the decision to use a respirator was based on the clinical severity of the respiratory failure. In less urgent cases, blood-gas studies were done.

Shock was treated initially by intravenous electrolyte solutions with the addition of sodium bicarbonate (100 Eq.) followed by blood transfusion where indicated. Blood was checked initially, and subsequently at least once daily, for PCO_2 and pH, haemoglobin content and electrolyte values. Strict fluid balance charts were kept. Frequent clinical examination and serial X-ray examinations of the chest were made to detect the presence of complications such as pneumothorax, haemothorax, bronchospasm, atelectasis, etc., and these were treated as required.

Patients on respirators were treated by the Respiratory Unit of Johannesburg Hospital. Those treated with an Engström respirator required an average of 15 days' treatment until entirely free of the respirator.

Routine tracheostomy care consisted of the introduction of 5 - 10 ml. of sterile saline into the trachea every ½-hour, followed by suction through a sterile catheter. The pressure in the bulb of the tracheostomy tube was released for a few minutes every ½-hour.

The tracheal secretions were examined daily for bacterial and fungal infection. *P. pyocyaneus* was found in 11 patients, *Staph. aureus* in 8, *Klebsiella aerogenes* in 6 and *Candida albicans* in 4 cases.

An X-ray examination of the chest was made every morning until the acute phase had passed. This was done not only to assist the clinical assessment but also because a pneumothorax or haemothorax—not present initially—might develop later.

Of the 52 patients, 16 died, i.e. an over-all mortality of 30·7%.

Of those who died, 7 patients had severe head injury, and 4 patients suffered from pre-existing severe disease at the time of their injury. Two had previous coronary thrombosis, and 2 had chronic lung disease. One patient died from pulmonary embolism. Two died before they could be given adequate artificial respiration. One patient had a ruptured diaphragm and developed acute intestinal obstruction. He died postoperatively of gas-gangrene.

Thus death was directly attributable to the chest in only 3 of the 13 fatal cases.

SUMMARY

A retrospective study of 362 cases of chest injury has been made. Patients with severe contusions of the chest, but without fractures, merited admission. In some patients an ECG showed myocardial contusion, and serial chest X-rays showed the development of pneumothorax, or contusion of the lung.

Strapping was not used for treating fractures of the ribs. Intercostal nerve blocks were employed to obtain pain-free respiration and coughing.

Pneumothoraces of over 20% in size were treated by intercostal tube drainage.

Severe brain injury accompanied by a thoracic injury significantly increased the mortality.

Rupture of the bronchus was suspected in the presence of a continuous loss of a large amount of air from a tension pneumothorax, even though bronchoscopy was negative. Treatment is by thoracotomy even if the tear is not seen on bronchoscopy.

The possibility of a mediastinal haematoma should be kept in mind whenever a chest injury due to severe sudden deceleration occurs. The only reliable sign is widening of the mediastinum as seen on X-ray examination. Urgent aortography and treatment are necessary, as rupture occurs within hours of the time of the injury.

The treatment of the flail chest depends primarily on the extent of interference with respiration.

The over-all mortality of 362 patients with chest injuries was 7·5%.

I wish to thank Dr H. van Wyk, Medical Superintendent of Johannesburg Hospital, for permission to use these records, and the Respiratory and Thoracic Surgical Units for their co-operation.

REFERENCES

1. Shrier, G. and Stein, A. (1964): J. Coll. Radiol. Aust., **8**, 48.
2. Schrire, T. (1962): S. Afr. Med. J., **36**, 747.
3. Des Forges, G., Striedet, J. W., Lyncg, J. P. and Madoff, I. M. (1957): J. Thorac. Surg., **34**, 779.
4. Carter, M., Guiseffi, J. and Felson, B. (1951): Amer. J. Roentgenol., **65**, 56.
5. Schwindt, W. D. and Gale, J. W. (1967): Arch. Surg., **94**, 330.
6. Maloney, J. V., Schmutzer, K. J. and Raschke, E. (1961): J. Thorac. Cardiovasc. Surg., **41**, 291.
7. Van Hasselt, H. and Marchand, P. (1964): S. Afr. J. Surg., **3**, 1.