PENETRATING STAB WOUNDS OF THE CHEST

A. STEIN, F.C.S. (S.A.) AND G. SCHNIER,* D.M.R.D. (LOND.), D.M.R.D. (RAND), *Departments of Surgery and Radiology, Baragwanath Hospital and the University of the Witwatersrand, Johannesburg*

Penetrating stab wounds of the chest constitute an ever-present problem in many hospitals in South Africa. At Baragwanath Hospital, where approximately 1,500 cases are admitted annually, our experience in common with many other workers is that the mortality rate is steadily decreasing. Peace-time figures only are quoted, since war-time injuries involve tearing injuries by high velocity fragments as compared with the simple incised wound, common in peace-time.

Representative mortality rates are: Boland[2] (1935) 13%, Elkin and Cooper[7] (1942) 6·2%, Skapinker[15] (1949) 6%, Gray *et al.*[8] (1960) 3·8%, Garzan *et al.*[9] (1964) 2%, and Baragwanath Hospital (1963) 1·6% (including those cases with thoraco-abdominal wounds who died during the post-operative period).

The purpose of this paper is to discuss the factors operating in the patho-physiology of this condition and the treatment in relation to the patho-physiology, resulting in the lowered mortality rate.

PATHO-PHYSIOLOGY IN PENETRATING WOUNDS OF THE CHEST

Penetrating injuries of the chest produce ill-effects as a result of the following factors:

1. Blood-loss and shock.
2. Impairment of pulmonary ventilation owing to:
   (*a*) presence of air and blood in the pleural space, causing partial or complete collapse of lung,
   (*b*) injury to pulmonary parenchyma, diaphragm and chest wall,
   (*c*) pain with fixation of the hemithorax, and
   (*d*) phenomenon of 'pendelluft'.
3. Reduced cardiac output owing to:
   (*a*) reduced venous return, due to loss of negative pressure within the thoracic cage, loss of circulating blood volume by internal or external haemorrhage or kinking of large veins due to mediastinal shift, and
   (*b*) cardiac tamponade.

The collapse of the lung may have to its credit a beneficial effect, in that it causes a reduction of the volume of circulating blood and air within it, and so lessens the loss of blood and air from the injured lung. This is why progressive increase of a haemothorax or pneumothorax is uncommon. When it does occur, it is usually due to involvement of a major bronchus or vessel such as hilar, intercostal or internal mammary vessels. These are the cases that frequently die within a few hours of injury or fail to respond to adequate resuscitative measures.

Pneumothorax

Function tests have shown that a pneumothorax causes a marked reduction in ventilatory reserves. This will return to normal with re-expansion of the lung, in the absence of any complicating factor in the pleural space. This decrease in ventilatory reserve may become permanent if a layer of fibrin is deposited over the lung, preventing re-expansion when adhesions form or pleural thickening occurs. Therefore we aim to obtain re-expansion as soon as possible by conservative means when feasible, and by active means when not.

Haemothorax

This produces a number of effects:

1. Blood in the pleural space represents blood lost from the circulation. If the amount is large it may cause shock.
2. Blood in the pleural space may cause impairment of ventilation and may diminish venous return to the heart.
3. Blood in the pleural cavity acts as an irritant. The pleura responds with a serous exudation and causes an increase in the amount of fluid seen in the chest. It is important that this should not necessarily be interpreted as fresh bleeding. The question of the response of the pleura to the presence of blood was investigated by Nicholson and Scalding[12] and Langston and Tuttle.[10] They found a definite reduction in the red cell and protein content of the pleural fluid, most marked after 7 days. In our series 18·4% of cases showed an increase in the pleural fluid, which probably represented pleural exudation. Regardless of whether the chest is filling with blood or exudate, the aim should be to remove it as soon as possible, since Langston and Tuttle[10] found that in these cases there was a thin layer of fibrin over the lung, which could not be seen on radiographs.

Clotted Haemothorax

This is a phenomenon which has not been adequately explained. It occurred in 8% of cases. It may occur over a time period of a few minutes to a few days. Adams[1] believes it to be associated with a severe injury or sepsis. Langston and Tuttle[10] and Nicholson and Scalding,[12] on the other hand, could find no evidence that it was in any way associated with the type or severity of the injury, size of the haemothorax or infection. Our impression is that in some cases it may be related to the rapidity of bleeding. In the thoracotomies we have performed for massive haemothoraces due to stab wounds into the heart, large vessels or thoraco-abdominal wounds, the blood in the pleural cavity has been clotted.

The clotted haemothorax is a solid mass which accumulates at the base of the pleural cavity. It consists of 3 layers: a tough outer layer applied to the pleura, a layer of unorganized fibrin of varying thickness and a central loculated cavity filled with fluid of varying colour. Histologically the outer layer is an organized fibrinous layer invaded by capillaries and containing fibroblasts. The depth of the reaction is dependent on the age of the clot and may be well advanced in 7 days.[10]

Crawshaw[3] believed that clotting and loculation in the absence of underlying pathology and infection is usually a transient phenomenon and does not lead to organization, failure or re-expansion of the lung or a frozen chest. He also stated that the pleura has an unlimited capacity to

*Present address: 29 Will St., Kew, Melbourne, Australia.

absorb blood spontaneously, provided that functional activity of the lung was encouraged. Removal of the blood was therefore unnecessary unless respiratory distress was present. Most workers do not share these views[6,10-12] nor do most surgeons at Baragwanath Hospital do so at present. They believe that reabsorption of more than moderate amounts of blood takes place slowly and frequently leaves marked pleural thickening and other sequelae, viz. elevated diaphragm, narrowing of intercostal space, and reduced movement of the chest wall. Further, only in exceptional cases was full movement present after 6 months with no radiological evidence of pleural thickening.

Langston and Tuttle[10] found that if a frozen chest occurred, it often remained frozen despite radiological clearing, and that thick masses of fibrin were still present in the costo-phrenic region 6 - 8 weeks after radiological clearing of the chest. It has been further suggested that bacteria may reside in these fibrinous masses and lead to repeated episodes of infection.

Another complication in long-standing collapse of the lung is the obliteration of the pulmonary vascular bed.[17] Even though re-expansion of the lung by decortication is later produced, lung function may not return to normal. Although alveolar ventilation may return to normal, there is reduced alveolar gas exchange and an increase in the dead-space air and impaired or absent alveolar-capillary diffusion. According to Carrol *et al.*,[5] 4 years presents the critical period during which normal function can be restored by the surgeon.

On consideration of the patho-physiology, it would appear that the aim should be to produce re-expansion of the lung as early as possible and to drain the haemothorax, both to aid re-expansion and prevent fibrinous deposition. These principles were employed in the treatment of 615 cases which are analysed and discussed.

DISCUSSION

During the 26-month period 1 December 1962—31 January 1965 720 cases of stab-wound injuries of the chest were admitted to one of 5 similar surgical units at Baragwanath Hospital. The 720 cases (Table I) constituted 13% of all admissions to the unit during this period. All cases of stab wounds of the chest are included, and comprised non-penetrating wounds, simple stab wounds of the chest, stab wounds into the heart and thoraco-abdominal wounds.

TABLE I. STAB WOUNDS OF THE CHEST*

Total Number Admitted	*720*
Non-penetrating	105
Haemothorax	127
Pneumothorax	215
Haemo-pneumothorax	224
Surgical emphysema only	30
Thoraco-abdominal	30
Penetrating wounds of the heart	13
Deaths	10
Lost to follow-up study	68

*1 December 1962 — 31 January 1965.

The 68 cases lost to follow-up study constituted a group with a minimal haemothorax or pneumothorax. The majority attended the follow-up clinic on only 1 occasion, usually 5 or 10 days after their discharge, and returned to work immediately. They have probably all recovered. 105 patients proved to have non-penetrating wounds and are therefore excluded from the series. All the remaining patients were followed-up for a minimum period of 4 months or until radiologically clear.

Age of patients (Table II). This shows that we are dealing with a younger age group; 89% are less than 40 years of age.

TABLE II. AGE OF PATIENTS

	No. of cases	%
10 - 20 years	112	21·7
21 - 30 years	233	45·2
31 - 40 years	114	22·1
41 - 50 years	44	8·5
Over 50 years	13	2·5

64·8% under 30 years of age

Radiological Features

These features were dealt with in a previous paper,[14] and we therefore wish to stress only 4 points:

1. In order to meet the requirements of a simple linear measurement to assess the progress of the lesion, we have simply divided the hemithorax into 10 horizontal planes between diaphragm and apex, and labelled each one 10%. Similarly we have divided the hemithorax into 10 vertical planes between hilus and periphery to assess pneumothorax.[14]

2. Intra-pulmonary haematoma occurred in 16 cases. The importance of the lesions is that they may take 6 months to disappear and may be confused with other more sinister lesions of the lung. The history and the fact that from the time of injury these lesions become more clearly defined, smaller and denser, should prevent any difficulty in diagnosis.

3. Surgical emphysema was present in 36·5% of cases and is of little clinical significance unless it is very gross, when it may cause discomfort to the patient. In these cases an intercostal drain should be inserted into the second intercostal space anteriorly. This was necessary in 4 patients. In the remainder, the emphysema cleared in 1 - 2 weeks. No relationship between the size of the pneumothorax and the degree of surgical emphysema could be determined. Gray *et al.*[8] found that the larger the wound, the greater the degree of subcutaneous emphysema present.

4. Mediastinal emphysema occurred in 5% of cases. It has little clinical significance, except to make one consider the possibility of an oesophageal laceration, especially when it occurs without an associated pneumothorax. This is more likely if the emphysema occurs in the root of the neck.

TREATMENT

The routine followed in the treatment was the same in all cases. They were seen initially in the casualty department, where their wounds were sutured without debridement. In none of these cases did wound sepsis occur. If they were shocked, they were admitted directly to the ward, otherwise they were first radiographed.

In the ward they were assessed clinically, particularly as regards the presence of shock, respiratory distress, cardiac tamponade or evidence of intra-abdominal perforation.

Here we must mention that there is frequently a discrepancy between radiological findings in the casualty department and the clinical findings on arrival in the ward. Very often, although the radiological changes were minimal, the clinical picture was that of a tension pneumothorax. A large number of patients are hypotensive on admission. Most of these smelt strongly of alcohol, and showed no evidence of marked blood loss or major injury. They usually responded dramatically to bed rest or small amounts of intravenous fluids, particularly dextrose solutions.

Apart from the local lesions of the chest wall, all patients were administered as a routine procedure:

1. Blood, plasma or intravenous fluids if shocked;
2. Antibiotics—usually penicillin and streptomycin;
3. Physiotherapy;
4. Analgesics if required;
5. Early ambulation was enforced; and
6. All patients were radiographed after 48 hours and again on the 5th day, and thereafter at varying intervals until their chests were clear of blood.

The treatment of the haemo- or pneumothorax was based on the size of the lesion. As a general rule a haemo- or pneumothorax of greater than 15% was treated by some form of drainage procedure. An arbitrary size of 15% was chosen, since past experience has shown that in patients with a lesion less than 15% re-expansion and reabsorption readily occurred without complications. This system was also found effective by Garzan *et al.*[9]

Table III gives an analysis of treatment in the series.

TABLE III. TREATMENT OF HAEMO- AND PNEUMOTHORAX

Treatment	*No. of cases*	*Indication*
Conservative	318 (51·7%)	Surgical emphysema only —30 cases Haemothorax—156 cases Pneumothorax—120 cases Heart injury—12 cases
Aspiration	62 (10·9%)	All haemothorax
Intercostal drains	229 (37·2%)	Haemothorax—95 cases Pneumothorax—134 cases
Thoracotomy	1	Stab wound of heart
Deaths	5	Received only emergency resuscitative treatment

Pneumothorax

Table IV shows that 289 patients were treated for pneumothorax. In those 156 treated conservatively, it was found that the rate of reabsorption of air was not dependent on the size of the pneumothorax. Some patients with a small pneumothorax took 14 days to clear, while others with a 20% pneumothorax cleared in 5 - 6 days. This may depend on the completeness of closing of the alveolar-pleural fistula or of pleural thickening owing to previous lung pathology. Average time to clear was 7·8 days and average hospital stay was 2·8 days.

TABLE IV. 289 CASES OF PNEUMOTHORAX

Treatment	*Number of cases*	*Average days to clear*	*Average days in hospital*	*Empyema*	*Deaths*
Conservative	156	7·8	2·8		
Intercostal drain (over 15% pneumothorax)	133	9·2	5·3	0	2
Bronchoscopy	8				

The remaining 133 patients with a pneumothorax greater than 15% were treated by the insertion of a size 28 or 30 Malecot catheter in the second interspace anteriorly in the midclavicular line, with an underwater seal and negative suction of 3 lb./sq. in. Average time for re-expansion was 9·2 days and average hospital stay was 5·3 days.

The practice of using a needle instead of an intercostal drain is to be condemned for the following reasons. It may lacerate the re-expanding lung; it becomes blocked easily; and furthermore the bore is too small to cope with a large fistula if present. The only indication for using a needle is as an emergency measure in a tension pneumothorax, and should be replaced by a catheter as soon as possible.

Negative suction, condemned in the past, has been found to be very effective in all cases, particularly in the uncooperative patient. By its use, re-expansion of the lung is more rapid and the catheter can be removed much earlier —in 6 - 12 hours in many cases. This is especially valuable in hospitals with a marked shortage of bed space. No cases of collapse or shock occurred. It is important to note that if the pressure used is much in excess of 3 lb./sq. in., the patients complain of severe chest pain.

In 9 patients, despite intercostal drainage and negative suction, and with no evidence of a major broncho-pleural fistula, the lung failed to re-expand in 5 days. These patients were anaesthetized and then examined with a bronchoscope. Any blood or mucus present was sucked out and the lung was then inflated through the bronchoscope. In all 9 cases the lung re-expanded and remained expanded. It is postulated that by the 5th day, the pleural surfaces are covered by a sticky layer of fibrin. When the lung expands it adheres to the pleural surface, thus sealing a peripheral fistula, which had maintained the pneumothorax.

Thoracotomy is indicated in those patients in whom a major bronchus is injured, or where a broncho-pleural fistula is still present after 10 - 14 days. The majority of broncho-pleural fistulae close spontaneously. Thoracotomy was not indicated in any case of pneumothorax in this series. No cases of empyema occurred in this group.

The use of an intercostal drain in pneumothorax without respiratory distress may be criticized on the grounds that, from the experience gained with artificial pneumothorax, it is unnecessary. The question is now being investigated and a series is being conducted, where intercostal drainage is reserved only for those cases showing respiratory distress, or if there is no radiological evidence of re-expansion after 48 hours. If after a further 48 hours with intercostal drainage, no re-expansion has taken place, bronchoscopy and inflation of the lung is carried out.

Haemothorax

There is as yet no unanimity of opinion as regards the best method of treatment. The methods advocated are:

1. The conservative treatment of all cases, unless respiratory distress is present.[3,7,13]

2. Aspiration of all haemothoraces irrespective of size as soon as possible and as often as is necessary to remove

all the blood present.[5,16]

3. Intercostal drainage with or without negative pressure suction, if there is sufficient blood to obliterate the costo-phrenic angle.[4,6] Gray[5] advocates its use only if there is a large haemothorax, or if a haemothorax recurs after aspiration, which is also our policy.

The treatment carried out in this series was conservative if the haemothorax constituted 15% or less, aspiration if from 15% to about 35% and by intercostal drainage and negative pressure suction if the haemothorax constituted greater than 35 - 40% in size. Table V gives an analysis of the treatment carried out, the average time to clear and average hospital stay in 277 cases of haemothorax.

TABLE V. 277 CASES OF HAEMOTHORAX

Treatment	*Number of cases*	*Average days to clear*	*Average days in hospital*	*Empyema*
Conservative	120	10·5	3·0	
Aspiration only (15-35% haemothorax	62	15·0	5·0	
Single aspiration	31			0
Multiple aspiration	31			1
IC drains (greater than 35% haemothorax)	95	15·2	7·3	12

Where intercostal drainage was regarded as necessary, a size 30 Malecot catheter was inserted in the 7th or 8th intercostal space in the posterior axillary line. We have found the Malecot catheter preferable to an ordinary catheter, since the ordinary catheter often fails to drain as it is pushed in above the level of the blood, whereas the Malecot catheter is pulled back and sits flush against the chest wall. In those cases with a large haemo- and pneumothorax 2 intercostal drains are inserted, to deal with the haemo- and pneumothorax separately.

It will be noted that there were 13 cases of empyema in this group. 8 of these were cases complicated by visceral perforation. In all except one case, the catheter was in for more than 48 hours. We do not know whether the period of drainage has any relation to the incidence of empyema or whether it was due to the fact that these were the more severe cases requiring longer periods of drainage.

The question of what form of treatment to adopt in the case of haemothorax is, we feel, answered by the low mortality and morbidity rate with active treatment in all but the small cases of haemothorax.

Clotted Haemothorax

This condition presents a problem and should be suspected when the amount of blood aspirated or drained is less than would be expected on the basis of the X-ray picture, and the diagnosis should be made before loculation occurs. In the past the patient was treated conservatively if aspiration or drainage failed, on the basis that this was a transient phenomenon.[3] In 16 cases treated in this way since the patients refused operation, there was still evidence of loculation, adhesions and reduced chest movement after 4 - 6 months. There was no evidence of underlying pulmonary pathology or infection.

The present treatment of the clotted haemothorax is conservative for the first 7 - 10 days. If no appreciable resolution has occurred in this period, pleural toilet is performed. A rib resection is performed and the clot is evacuated, following which an intercostal drain is inserted for 48 hours. This is a simple procedure if carried out within 10 days after injury; if it is left longer, then a formal decortication becomes necessary.

Decortication is indicated in those cases where re-expansion has failed to take place. This may be due to a fibrinous layer over the lung, a clotted haemothorax or empyema. This procedure was performed in 12 cases with no mortality and full expansion of the lung. In 7 cases it was for empyema and in 5 cases for a clotted haemothorax. The optimum time for decortication is within 21 days of the injury, when the fibrinous layer peels off fairly easily. It becomes increasingly more difficult after this time.

Thoracotomy is indicated where bleeding continues despite treatment. It was required in only one case in this series, due to laceration of the innominate vein.

Stab Wounds of the Heart

All patients suffering from stab wounds of the heart are treated conservatively, unless there is evidence of cardiac tamponade which does not respond to pericardial paracentesis or if a patient with a wound in the vicinity of the heart remains in a state of shock, despite adequate resuscitation. In these patients, thoracotomy is performed and the myocardial wound is sutured. Creech and Pearce[4] suggest that in cases where it is uncertain whether shock is due to blood loss or tamponade, a catheter should be passed into the inferior vena cava and the pressure measured. If the pressure is below 5 cm. of water it indicates a low cardiac output due to loss of circulation blood volume, and blood transfusion is indicated. If the pressure is above 12 cm. of water it indicates the presence of cardiac tamponade, which requires active treatment. Creech and Pearce[4] treat them all by paracentesis of the pericardium since they believe that the bleeding will cease spontaneously. Our experience, in cases outside the series under review, has been that bleeding often continues from atrial wounds and surgical intervention is required.

There were 13 cases in this series, all proven electrocardiographically. 12 were treated conservatively; in 3 pericardial paracentesis was carried out for cardiac tamponade. One was subjected to surgery. There was no mortality or complications in this group.

Thoraco-Abdominal Wounds

The diagnosis of abdominal involvement from stab wounds of the chest may be very difficult, since it is necessary to distinguish intra-abdominal lesions from reflex signs and symptoms of a simple chest injury. We have seen 6 patients in this period, originally diagnosed as simple chest injuries, return later with diaphragmatic hernias, symptomless, obstructed or strangulated. For this reason all patients in whom a diaphragmatic or intra-abdominal injury has been diagnosed, should be subjected to operation.

In the majority of cases a vertical abdominal incision is sufficient. In those cases where this exposure is inadequate, overseas authors suggest a separate thoracotomy incision rather than a thoraco-abdominal approach. In our experience, if the stab wound is posterior to the anterior axillary line on the right or posterior axillary line on the left a thoraco-abdominal approach is required. In those cases where liver injury alone is suspected, laparotomy is not undertaken. In all patients with thoraco-abdominal stab

wounds an intercostal drain should be inserted pre-operatively to prevent the possibility of a tension pneumothorax resulting from positive-pressure anaesthesia. We have seen this complication occur on a few occasions.

In this survey there were 34 cases of thoraco-abdominal stab wounds of which 30 were submitted to operation. Two patients refused operation, one of whom returned a week later with an obstructed diaphragmatic hernia, relieved by surgery. Of the 30 patients, only 5 required a thoraco-abdominal approach. Five patients had a diaphragmatic but no visceral injury. There were 4 deaths during the postoperative period and 5 patients developed empyema.

Progress

We have mentioned in discussing the patho-physiology of these injuries, that pleural exudation may occur. In fact 80 patients in this series (Table VI) showed a significant increase in the amount of fluid, and in 78% of these it was observed within 2 - 5 days after the injury. The possibility of this increase in size is the reason for repeating the radiography as a routine procedure on every patient after 48 hours and again 5 days after the injury. We have noticed too, that many cases of pneumothorax show an increase in size in this period. We have postulated[14] the following mechanism: The fistula, be it broncho-pleural, bronchiolar pleural or alveolar pleural, becomes sealed by blood, or fibrin, on collapse of the lung, and that this seal becomes displaced with re-expansion of the lung, causing an increase or recurrence of the pneumothorax. This has no relationship to the treatment carried out previously. It is significant that 60% of the patients who deteriorated, had been treated conservatively (Table VI).

TABLE VI. PROGRESS OF LESION

	Cases	
Filled up with fluid or blood	80	13·9%
Filled up with air	46	8·1%
Filled up with air and blood	26	4·5%
Total	152	26·5%

40% were treated conservatively before increase took place.
60% were treated by ICD or aspiration before increase.

Further treatment

	Cases	
ICD	55	36·2%
Aspiration	20	13·2%
Conservative	77	50·6%

Time of deterioration was in 2-5 days in 78·0%

Although this increase only took place after 48 hours in 78% of cases, there were a significant number in which a marked increase occurred between the time they were examined by X-rays, which showed a minimal lesion, and the time they reached the ward.

RESULTS

Empyema

There were 13 cases of empyema in this series: 5 were associated with injury to intra-abdominal viscera and 3 with injury to the trachea. The remaining 5 cases were made up as follows: One case had no previous treatment before admission with empyema; one case followed multiple aspirations; and 3 cases followed intercostal drainage.

Gray *et al.*[5] in a series of 769 cases in 10 years, found that 80% of their patients were cured by a single aspiration, and that no case of empyema occurred in this group. Where multiple aspirations were required the incidence of empyema rose to 2·2%, which is also our experience. In view of these findings we feel that the haemothorax should be evacuated as completely as possible at the *first* aspiration. We have had no case of shock resulting from this method, and do not introduce air into the pleural cavity after aspiration.

We are of the opinion that the increased incidence of empyema, following intercostal drainage, is due to the fact that this is used in the more severe cases, and is also related to the length of time the catheter is left in. In all uncomplicated cases, particularly if negative suction is used and if drainage is adequate—i.e. the catheter is of adequate bore, and is not placed too high, too low or too far in—drainage will be complete within 48 hours. If drainage is not complete in this time, a complicating factor such as a clotted haemothorax should be suspected. In this event the catheter should be removed and the complicating factor treated accordingly.

It is our policy at present to remove all catheters after 48 hours and prevent multiple aspirations where possible. In those patients in whom this policy has been carried out, there has been no case of empyema.

Mortality

There were 11 deaths in this series, an over-all incidence of 1·6%. Five of the cases died either on arrival in the ward, before or during resuscitative measures, all within the first hour of admission. This was also the experience of Skapinker.[15]

In 2 cases death was due to a stab wound of the heart, and in one case a severed subclavian artery. Two patients were extremely shocked and showed no evidence of respiratory distress. At postmortem examination the only findings were small haemothoraces. One case died of a tension pneumothorax 12 hours after admission with a 20% pneumothorax. The remaining 5 cases had thoraco-abdominal stab wounds, and died during the postoperative period from peritonitis or pulmonary complications.

TABLE VII. TIME INTERVAL BETWEEN INJURY AND ADMISSION

Time in hours	*Number of cases*	*Percentage*
0 - 2	47	11·1
2 - 3	48	11·3
3 - 4	61	14·3
4 - 6	116	27·3
6 - 12	84	19·8
12 - 18	19	4·7
18 and over	49	11·5

52·9% admitted within 2 - 6 hours.

To try and explain the reason for almost all the deaths occurring within a short time of admission to hospital, an analysis of the time which had elapsed between the injury and admission was carried out. From Table VII it is seen that in the majority of cases this time lapse is in the region of 2 - 6 hours. This confirms the view expressed by Adams,[1] that if the patient survives the first few hours,

then the injury is to the smaller lung vessels and bronchi.

It is felt that this low mortality rate is due to the prompt attention to shock, antibiotics, physiotherapy and an active approach in correcting the abnormal pulmonary physiology produced by the injury.

SUMMARY

The ill-effects of blood and air in the pleural cavity is mentioned, both in the acute stage and in the late stages.

In 26·5% of cases there was an increase in the haemo- or pneumothorax within 2 - 5 days; the aetiology and its relationship to treatment is discussed.

The treatment and results of 615 cases of penetrating wounds of the chest is discussed, with particular reference to lowering the incidence of frozen chest and empyema. Factors affecting the mortality are mentioned.

We should like to thank Prof. D. J. du Plessis, for his advice and constructive criticism; Dr. W. Kenny, Medical Superintendent, and Mr. S. Kleinot, Principal Surgeon, of Baragwanath Hospital, for their permission to publish these cases.

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