MANAGEMENT OF STOVE-IN CHEST IN A PERIPHERAL CLINIC

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STOVE-IN chest is a relatively uncommon injury. There have been only three admissions to the Sunderland Group of hospitals during the period 1956-60 and this despite the fact that we serve a population of 390,000, in an area where there is a considerable amount of heavy industry, including shipbuilding and coalmining. Traffic passing through the town in the summer months to the seaside and coastal towns is quite heavy. In addition, a fourth case was treated in a hospital outside the town.

Stove-in chest may be an isolated injury or one of several sustained by a patient. In itself it is a serious injury and if inadequately treated can prove fatal. Outside special centres a surgeon seldom sees enough cases to learn how to treat these patients satisfactorily. The treatment given to our four patients, all of whom have survived, has not been ideal but it has depended on the circumstances under which we work, e.g. insufficient staff for instituting controlled respiration using a mechanical respirator, etc.

The Nature of the Problem

A stove-in chest results from: (1) Fractures of the anterior ends of the ribs or costal cartilages on both sides. This may be associated with a fracture of the sternum. (2) Double fractures of the lateral aspects of the ribs on one side.

The patient suffers from pain and respiratory embarrassment. Shock may be present as a result of paradoxical respiration and if there has been loss of a large quantity of blood. Control of the respiratory embarrassment is as urgent and important as the replacement of lost blood by adequate transfusion to prevent the patient from passing into an irrecoverable state.

Respiratory embarrassment results primarily from the paradoxical movement of the flail segment and is comparable to the problem presented by an open pneumothorax. The flail segment is

FIG. 1 (a).—Fractures of the anterior ends of the ribs or costal cartilages on both sides. This is associated with a transverse fracture of the sternum.

FIG. 1 (b).—Double fractures of the lateral aspects of the ribs on one side.

sucked in during inspiration and blown out during expiration. The result is that expired air, instead of being exchanged with the atmosphere, is shifted from the lung tissue under the flail segment into adjoining lung tissue and into the opposite lung. This results in anoxia and carbon dioxide retention. Associated pressure changes on the affected side of the chest cause movement of the mediastinum towards the opposite side on inspiration, the reverse occurring in expiration. This movement, called mediastinal flutter, interferes with the filling of the atria, with consequent circulatory disturbance.

The fractures themselves increase the embarrassment because pain reduces the expansion of the chest and thus reduces the tidal air.

Pulmonary oedema quickly supervenes and may be present on admission. The cause is not known. It has been suggested that there is a constriction of the pulmonary vessels in the lung tissue underneath the flail segment. The resultant anoxia causes oedema of the alveolar wall. In extensive injuries this constriction may cause pulmonary hypertension with further interference with the exchange of gases in the lungs. The diversion of extra blood through the normal lung may be another factor in causing oedema. Unconsciousness or severe pain, preventing coughing and clearing of the respiratory passages will, by increasing anoxia, provoke further oedema. Retained secretions quickly become infected with resultant bronchopneumonia (Barrett, 1960).

Hæmatoma of the lung, pneumothorax, hæmothorax, traumatic diaphragmatic hernia or cardiac injuries including tamponade, may be present with a stove-in chest and increase respiratory distress.

Finally, if the patient survives, an uncorrected deformity may permanently impair his respiratory function.

Case 1

A patient of 56, a blacksmith's striker in a shipyard, was admitted on 20.12.57 at 2.07 p.m., after being caught in a machine at work. A chronic bronchitic, he had sustained double fractures of his right 1st, 2nd, 3rd and 4th ribs. This had resulted in a large anterior flail segment and paradoxical respiration was obvious. His pulse rate was 90/min. and his blood pressure was 140/90 mm. Hg.

The fracture sites were infiltrated with 1% lignocaine hydrochloride followed by 2% benzocain in 40% urethane (whose anaesthetic action is prolonged) to relieve his pain and a pad and bandage were applied to the area of paradox in an attempt to control the flail segment.

At 8.30 p.m. he was cold and clammy, dyspnoeic, wheezing and bubbly. He expectorated a very small quantity of frothy sputum. His pulse rate was 100/min. and its volume feeble. His blood pressure was 100/70 mm. Hg. He was given intravenous injections of aminophylline and of ephedrine gr. $\frac{1}{2}$, but his condition deteriorated further.

At 2.30 a.m. he was given a general anaesthetic and with respiratory control his condition improved. The fractures were exposed through transverse incisions, splitting the pectoral muscles. Displaced fragments of his right 2nd, 3rd and 4th ribs were elevated and lengths of stainless steel wire were passed through holes drilled in the ribs on either side of the fracture sites. The wires were tied and the flail segment was thus stabilized, the right pleural cavity being drained by a Malecot catheter. His bronchial tree was cleared of secretion by bronchoscopy, and he was given one pint of blood.

Following the operation his condition continued to improve. A *B. coli* pneumonitis of his right middle and lower lobes responded to a course of streptomycin. A wire in his right 2nd rib snapped and was removed under a local anaesthetic on 14.1.58. He was discharged home on 15.1.58, returning to work on 11.6.58. The ribs united with slight flattening.

Comments

The following points are noteworthy:

- (1) The rapid deterioration without adequate treatment in a purely thoracic cage injury.
- (2) The marked improvement under general anaesthesia.
- (3) The maintenance of his general condition and a satisfactory convalescence after stabilization of his chest, even without tracheotomy.
- (4) The minor residual deformity.

Case 2

A guard of 60 years on British Railways was admitted at 11.50 a.m. on 19.8.58, after an engine had crashed into his guard's van. A chronic bronchitic for several years, he had sustained double fractures posteriorly of his left 6th, 7th and 8th ribs and a single fracture posteriorly of his left 9th rib. Anteriorly the costal margin was fractured with overlying surgical emphysema. He was slightly cyanosed and wheezy but no paradox was seen. A chest X-ray showed no air or blood in the pleura. He was given oxygen and injections of morphia gr. $\frac{1}{4}$, ephedrine gr. $\frac{1}{2}$ and 250,000 units of penicillin six-hourly.

His condition gradually deteriorated. His cyanosis was more marked, he became more dyspnoeic and at 7 p.m. on 20.8.58 he was semi-comatose. He was cold and clammy with a rapid feeble pulse; his chest was very wet and paradoxical respiration was now obvious over the 7th, 8th and 9th ribs antero-laterally. Further chest X-ray (Fig. 2) showed a left pleural effusion.

Under local anaesthesia (no anaesthetist being in the hospital) through an incision down to his left 7th, 8th and 9th ribs, his chest was stabilized by bunching the ribs together with three deep sutures of No. 3 catgut and one suture of stainless steel wire round the ribs, keeping close to their deep surfaces to avoid the lung. After this his chest moved naturally without any suggestion of paradox. His bronchial tree was cleared of foul green pus by bronchoscopy. For the first time his colour became pink.

Following the operation he was given oxygen and chloramphenicol in addition to penicillin. His condition improved through the night and he regained consciousness two hours later. His pulse rate fell and its volume improved. He was encouraged to cough up his sputum hourly and he did this satisfactorily.

Steady improvement followed with gradual absorption of a small left pleural effusion. He went home on

FIG. 2.—Case 2, 25.8.58. Showing double fractures of his left 6th, 7th and 8th ribs posteriorly, single fractures of his 9th rib and a left pleural effusion.

17.9.58 and never attended for a check-up after three weeks as he felt strong enough to return to work.

Comments

(1) Paradoxical respiration may only become obvious as the patient's condition regresses unless the surgeon is looking for it.

(2) Deterioration occurred without adequate treatment.

(3) An almost moribund patient withstood corrective procedures satisfactorily.

(4) Marked improvement followed the stabilization of his chest and bronchoscopic aspiration. Tracheotomy was again unnecessary.

(5) Although the administration of morphia probably did not influence the prognosis, it is better to avoid its use unless the patient can still be stimulated to raise his secretion.

Case 3

A labourer, aged 33, was crushed beneath a lift at about 6 p.m. on 1.6.59 and admitted at 7 p.m. He was semicomatose and restless. His breathing was shallow and paradoxical in the upper part of his chest. He was cyanosed with a feeble pulse of 110/min.

The flail segment consisted of the sternum and costal cartilages opposite the 2nd, 3rd and 4th ribs. It was covered by a pad and bandage. His restlessness was controlled by administration of gas and oxygen and morphia, gr. $\frac{1}{4}$. An endotracheal tube was then passed

FIG. 3.—Case 3, 2.6.59. Showing double bony fractures of his left 1st and right 2nd ribs and single fractures of his left 2nd and 3rd ribs. The endotracheal tube is in position. Hæmatoma in both upper zones.

under pentothal and scoline anaesthesia and administration of oxygen was continued.

X-ray (Fig. 3) showed double fractures of his right 2nd and left 1st ribs and single fractures of his left 2nd and 3rd ribs. The right 1st, 3rd and 4th costal cartilages were also fractured.

His condition improved. At 11 p.m. his depth of unconsciousness had become lighter. His pulse rate was 100/min. and of better volume. His blood pressure was 90/60 mm. Hg. An injection of A.T.S. was given as his chest was covered in abrasions and he was put on a course of penicillin.

The following day he could obey simple commands. His colour was pink, his paradoxical respiration was under control, his pulse rate was 85/min. and its volume was good. His systolic blood pressure had risen to over 100 mm. Hg. A lesion of the 5th, 6th and 7th cervical roots of his left brachial plexus and a dislocation of his right sterno-clavicular joint now became manifest.

His endotracheal tube was removed on 3.6.59. Chest X-ray (Fig. 4) showed paralysis of the left leaf of his diaphragm, collapse of the lower lobe of his left lung and segmental collapse in the middle and lower lobes of his right lung. Twice at bronchoscopy retained secretion was removed from his bronchial tree and the collapsed lung tissue re-expanded. It was also noticed that his left vocal cord was paralysed. His left recurrent laryngeal nerve had been damaged at the time of the accident.

He gradually improved. Evidence of voluntary contraction in the paralysed muscles was noticed on 4.6.59. He was discharged home on 11.6.59 after being

FIG. 4.—Case 3, 10.6.59. Residual shadowing in his right middle and lower lobes. Segmental collapse of anterior basal segment of lower lobe of left lung and paralysis of the left leaf of his diaphragm.

fitted with an abduction splint to continue the rehabilitation of his left arm as an out-patient. All his paralysed muscles recovered and he returned to work on 14.11.59. The only deformity which was present was due to an unreduced dislocation of his right sternoclavicular joint.

Comments

(1) His poor general condition on admission as a result of paradoxical respiration.

(2) Marked improvement occurred after control of the paradox by administration of an anaesthetic and passage of an endotracheal tube.

(3) It was remarkable that a large paradox was so much under control within two days that it was possible to remove the endotracheal tube and a tracheotomy was unnecessary.

Case 4

A civilian, aged 31, attached to the United States Air Force was admitted to a peripheral hospital at 6 p.m. on 4.9.59 after being involved in a road accident.

He was pale and shocked, his pulse rapid and feeble and his blood pressure 70/50 mm. Hg. He was suffering from gross paradoxical respiration due to fractures of his right 2nd, 3rd, 4th, 5th and 6th ribs laterally and separation of his right 2nd, 3rd and 4th chondro-sternal junctions. The flail segment of chest wall 6 in. in diameter was depressed and there was surgical emphysema over the front of the upper part of his chest. He was covered in abrasions, bleeding from his nose and

FIG. 5.—Case 4, 4.9.59. Showing collapse of his right lung, a right hæmopneumothorax, a small left pneumothorax and a broad mediastinum (hæmatoma).

coughing up fresh blood. He vomited three times, the vomitus consisting of altered blood.

Chest X-ray (Fig. 5) showed, in addition to the fractured ribs (of which the 3rd was comminuted), collapse of his right lung, a right hæmopneumothorax, a small left pneumothorax and a broad mediastinum.

A transfusion of one pint of plasma (which was subsequently followed by nine pints of blood) was started and the depression in his chest wall was covered by a pad and bandage. One of us, called to see him, re-strapped his chest and drained the right hæmopneumothorax with an intercostal Malecot drain.

At 7.30 p.m. his pulse rate was 120/min. but the volume was good and his blood pressure was 120/80 mm. Hg. During the night his condition deteriorated. He became deeply cyanosed, respirations became more laboured and though his pulse rate remained 120/min., and the volume was good, his blood pressure rose to 130/80 mm. Hg (because of anoxia and carbon dioxide retention).

Tracheotomy was performed at 11 a.m. as a result of which his condition became less desperate. His breathing became less laboured though he still remained rather cyanosed. As a result of his persistent respiratory inadequacy, he was restless and confused, i.e. there was evidence of cerebral anoxia. Again one of us was called to the peripheral hospital and it was decided to carry out a stabilizing operation.

At mid-day on 5.9.59 under a general anaesthetic the flail segment was exposed through an oblique incision over the front of the right side of his chest, starting over his right 2nd costal cartilage and extending downwards and laterally to the anterior axillary fold. His right lung was punctured and contained a large hæmatoma. There

FIG. 6.—Case 4, 6.9.59. Showing consolidation and haematoma of both lungs and mediastinum. The right lung is now expanded. The tracheotomy tube and right Malecot drainage catheter are in position and the wires approximating the fragments of his right 2nd, 3rd and 4th ribs can just be seen.

was a massive haematoma in his superior mediastinum. The rents in the lung were sutured, the flail segment was elevated and stabilized by wiring the fractured fragments of his right 2nd, 3rd and 4th ribs and right 2nd, 3rd and 4th chondro-sternal junctions together with stainless steel wire. Both pleural cavities were drained.

At 4.30 p.m. he was no longer cyanosed and though his chest wall moved much more satisfactorily, minimal paradox was still present. Chest X-ray showed massive shadowing in the right lung and considerable shadowing in the left lung.

On 6.9.59 he was still semi-conscious and restless but his colour was good and respirations were not laboured. His pulse was 120/min. and of good volume. His blood pressure was 130/80 mm. Hg. His chest X-ray (Fig. 6) showed that his right lung had expanded though there was an opacity in the middle lobe. There was a slight residual left pneumothorax. He was transferred to another hospital with a positive pressure respirator as he was still semi-conscious. He remained critically ill for seven days and did not regain full consciousness for four days. His condition thereafter steadily improved.

He left hospital on 5.10.59. Minimal paradox persisted at the lower end of his sternum on deep breathing; otherwise his chest was satisfactory. His wounds had healed and there was no gross residual chest wall deformity. (Chest X-ray, 1.12.59, Fig. 7.)

Comments

(1) Deterioration of the patient's condition occurred without adequate treatment, i.e. tracheo-

FIG. 7.—Case 4, 1.12.59. Lungs expanded and clear. Mediastinal shadow within normal limits. The wires are visible.

tomy, stabilization of his chest or positive pressure respiration.

(2) His definite improvement after tracheotomy facilitated the next phase in treatment.

(3) The stabilization operation was well withstood and this procedure allowed repair of the lung trauma. From this point the patient's condition improved steadily.

(4) There was only slight residual deformity.

Discussion

The treatment available for a large stove-in chest consists of: (1) Positive pressure respiration with tracheotomy. (2) Stabilization of the chest wall. (3) A combination of the above measures.

For minor cases a combination of strapping with relief of pain by intercostal block or morphia derivatives and bronchoscopy is all that is necessary.

Positive-pressure respiration is very satisfactory provided there is adequate staff available to carry it out. This method is impracticable outside special centres because of inadequate staffing. The operation of a mechanical respirator requires a certain amount of skill and cannot be left to the nursing staff, unless they have been specially trained. It is easy to carry out positive-pressure

respiration through an endotracheal tube but as the tube cannot be kept in for more than 48 hours a tracheotomy then becomes necessary. It requires more skill to maintain positive-pressure respiration through a tracheotomy and the operation itself is not without its dangers. Positive-pressure usually would have to be continued for several days to stabilize the chest.

Stabilization of the chest wall can be carried out by traction (Proctor and London, 1955), or actual repair of the flail segment by wiring (Bickford and Grant, 1956) or by special nails. We have no experience of traction. The descriptions in the literature envisage a certain amount of operative interference, complicated appliances and a prolonged period of traction, i.e. two to three weeks with a certain amount of discomfort to the patient. It has the advantage that no special experience of thoracic surgery is required. Actual repair of the chest wall can be carried out by a relatively simple operation of wiring or suturing the fragments together. Damage to structures inside the thorax can be dealt with at the same time. Following the operation it appears that the patient's convalescence is usually comfortable and easy to manage. There is very little residual deformity.

Fig. 1 (a) is reproduced with kind permission of the Editor of the *Journal of Bone and Joint Surgery*.

Conclusions

(1) A minor degree of paradoxical respiration may easily be missed unless looked for. As the patient's condition deteriorates it will become evident.

(2) Though in one case the nature of the respiratory distress was such that the patient's respiration could only be controlled by the administration of an anaesthetic, there was still time in the four cases to assess the patient's condition and exclude the possibility of other injuries.

(3) Once the patient has been assessed by physical examination and X-ray and the treatment of shock, when present, has been started by transfusion, the control of the paradoxical respiration is an urgent problem. Pads and bandages are not the answer. Ideally positive-pressure respiration should be established with a tracheotomy. This will allow control of his respiration with improvement in his general state.

(4) Fixation of a flail segment in ill patients resulted in immediate improvement in the condition of the three patients in which this simple operation was done.

(5) In two out of three cases, where the ribs were wired, a tracheotomy was not necessary.

(6) The cosmetic results in the wired patients were good. In one the chest wall returned to normal while in two cases there was slight residual depression.

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