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Acute right heart strain after crushing injury at Hillsborough football ground

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Ninety five people died from crushing injuries and asphyxiation at Hillsborough football ground in April 1989. Eighty one others were admitted to hospitals in Sheffield. Of the 18 patients who required artificial ventilation, five were transferred to this hospital for treatment and computed tomography of the head, and one further patient was admitted to this hospital. In all six men (aged 15-23) the brain scan was normal, though they had been asphyxiated by crushing and cerebral hypoxia had occurred. Five had epileptiform convulsions; one had bilateral pneumothoraces and one negative results on laparotomy. None had bone injuries. We report the effect of asphyxiation on cardiac function in these six young men.

Patients and methods

All six patients were ventilated and examined on admission. Electrocardiograms were recorded daily and echocardiograms on day one and day three or four. Blood samples were taken within the first 24 hours and on days two and three after injury to measure creatine kinase activity, including the myocardial isoenzyme and lactate dehydrogenase isoenzyme 1 activities.

In two patients the initial electrocardiogram showed a nodal rhythm and in one left axis deviation and left bundle branch block. The other four were in sinus rhythm, and by day two all were in and remained in sinus rhythm. The electrical axis was rightward ($+90^\circ$) in four patients initially, and one patient developed right axis deviation by day two.

There was a dominant R wave in V1 with an RsR pattern in two patients and this appeared by day three in three further patients. T wave inversion developed in leads V1 to V5 in three patients and resolved within two weeks.

Initial echocardiograms showed dilated and impaired right ventricles in four patients. Left ventricular function was reduced in three due to septal hypokinesia. The mean ejection fraction was 0.66 (range 0.46-0.85), becoming normal in all (mean 0.83, range 0.7-0.9). Two patients had small transient pericardial effusions, and three had persistent abnormalities of right ventricular function.

The total creatine kinase activity was appreciably raised, being compatible with muscle damage, but the cardiac isoenzyme fraction was not raised and the cardiospecific lactate dehydrogenase fraction was slightly raised in all patients (maximum 34% of total lactate dehydrogenase activity, normal $<25\%$).

Comment

In all six patients the apparent injury was similar—thoracic compression causing hypoxia, loss of consciousness, and convulsions. Unusually, there was no

Serial electrocardiographic recordings in one patient. On day one there was right axis deviation, sinus rhythm with blocked atrial premature beats and sinus arrest and nodal escape beats, partial right bundle branch block, and non-specific ST and T wave changes in V3 and V4. On day three axis is $>+90^\circ$, and there is complete right bundle branch block. There is marked T wave inversion in V1 to V5. On day 14 the axis remains at $+90^\circ$, and there is partial right bundle branch block and the T wave changes have resolved.

bone injury. Most cardiac abnormalities after crushing injury occur from blunt trauma after road traffic accidents, where deceleration causes damage to the anterior right ventricle. Electrocardiograms and cardiac enzyme activity are not sensitive indicators of this injury, but radionuclide scanning or echocardiography show abnormalities of right ventricular function.^{1,3} Our patients had acute strain of the right heart because of severe pressure overload which occurs in asphyxiation or with a major pulmonary embolus. One patient only was haemodynamically compromised and required inotropic support.

Acute right heart strain may have occurred for several reasons. External compression, especially of the abdomen, causes increased filling of the right heart. Thoracic compression produces a rise in intrathoracic pressure and pulmonary artery pressure, which would rise further from an increase in pulmonary vascular resistance secondary to hypoxia. The possibility of a pulmonary fat embolus from a crushing injury could not be excluded.⁴ Finally, direct cardiac trauma and contusion of the septum and right ventricle was a

possibility, supported by pericardial effusions in two patients and transient conduction abnormalities in two.^{1,3} The electrocardiographic and echocardiographic appearances improved in all six patients, and possibly no long term cardiac damage occurred. We did not test cardiac function, however, and the abnormal right ventricular function may interfere with exercise and normal activity in these young men.

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Fine bore silicone catheters for peripheral intravenous nutrition in adults

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The finest silicone central vein infusion catheter, intended for neonates, has been shortened and adapted for peripheral vein infusion in adults. We hypothesised that this catheter, used with a lipid based nutrition solution suitable for infusion via a peripheral vein, most closely approached the requirements for preventing infusion thrombophlebitis. These include using a short, soft, and flexible fine bore biocompatible catheter; sterile insertion technique; and an infusion solution with an osmolality up to 1000 mmol/l and pH greater than 5.0.¹ We therefore studied the complication rate when using this very fine catheter for peripheral intravenous nutrition.

Methods and results

Consecutive surgical inpatients requiring intravenous nutrition were studied. A fine bore silicone catheter (inside diameter 0.3 mm, outside diameter 0.6 mm, Vygon, Nutricath-S Epicutaneo-cave catheter) was inserted 15 cm into a median cubital vein. A transparent occlusive dressing secured the catheter, allowing unrestricted arm movement and observation of the puncture site. The catheters were used only for delivering intravenous nutrition.

The nutrition solutions were aseptically prepared in the pharmacy in 3 litre bags with about 100:1 energy (kcal) to nitrogen (g) (0.42 MJ:1g nitrogen) and 70% of non-protein energy supplied as lipid. Vitamins, trace elements, and sodium heparin (1 unit/ml) were added routinely and ranitidine (200 mg/24 h) when indicated. Mean osmolality was 1084 (SD 6.6) mmol/l and pH 5.6 (0.3). Patients received more than 35 kcal/kg/day (0.15 MJ/kg/day) and 0.35 g nitrogen/kg/day using volumetric infusion pumps. Thrombophlebitis (judged by a single observer) was indicated by at least two of the following: erythema, pain, swelling, and tenderness. Phlebitis restricted to the catheter tip indicated chemical phlebitis, and two of the following indicated bacterial phlebitis: fever, heat, increased neutrophil

count, and induration with a positive culture from the catheter tip or protracted resolution of inflammation. Bacteraemia was diagnosed by blood culture. Catheter tip culture was performed routinely.

Forty six patients aged 13-89 years received 61 catheters for 704 treatment days. Indications for intravenous nutrition included: gut rest after major surgery (32), pancreatitis (7), active Crohn's disease (3), and other reasons (4). The median duration of infusion was nine days (range 5-60). Thirty four patients required only one catheter, while seven required more than one, and five required a central catheter for some period. Forty one patients were treated with peripheral intravenous nutrition alone until enteral feeding was re-established. The figure shows the probability of continued catheter function. There were 11 episodes of phlebitis (10 chemical, one bacterial) with five recorded at completion of treatment. The median period to phlebitis was seven days (range 5-19). Two episodes were due to spontaneous retraction of the catheter with extravasation. Overall the daily risk of phlebitis was 0.016 (11/704) with no instances of bacteraemia or septicaemia related to the catheter. One *Staphylococcus epidermidis* infection occurred at the insertion site without phlebitis and cleared without antibiotics. Subcutaneous extravasation of infusate occurred six times and fully resolved within 96 hours of the infusion being stopped at that site.

Comment

Conventional peripheral vein catheters used for non-irritant infusions are associated with an incidence of phlebitis of 30-100% after five days.² Lipid based

Probability that fine silicone catheters were functioning plotted against time in days as for life table analysis. Dotted line indicates probability of infusion thrombophlebitis