Intracardiac therapy following emergency thoracotomy in the accident and emergency department : an experimental model

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SUMMARY

For a select group of patients with penetrating chest trauma, immediate thoracotomy in the accident and emergency department offers the only chance of survival. Foley catheters have been used to achieve haemostasis in cardiac wounds but are not widely used for intracardiac fluid and drug administration during resuscitation. In an anatomical model designed to assess this procedure an average flow rate of 275 ml min^{-1} was achieved. The equipment required is readily available and easily assembled.

INTRODUCTION

The number of patients attending the Accident and Emergency Department at Glasgow Royal Infirmary with stab wounds has been shown to be increasing, the chest being the commonest site of injury (45% of patients) (Batey & MacBain, 1967; Swann *et al.*, 1985). These wounds frequently present as life threatening emergencies, but in the vast majority of cases they can be managed satisfactorily by tube thoracostomy (Mattox, 1989).

Patients with penetrating wounds of the heart who reach hospital alive can often be temporarily stabilized, allowing time for transfer to the operating theatre and formal thoracotomy by an experienced surgeon. However, in a small number of patients immediate thoracotomy is required in the emergency room in order to save lives (Rutherford *et al.*, 1989). Criteria for performing emergency room thoracotomy have previously been defined (Samelson *et al.*, 1987) (Table 1). Patients

Table 1. Criteria for emergency room thoracotomy.

Signs of life in the field
Short transport time to hospital (up to 15 min)
Cardiopulmonary resuscitation in progress
Agonal vital signs or complete arrest

presenting to the A&E department with no vital signs but who were alive at the scene have eventually made a full recovery following this procedure (Shamoun *et al.*, 1989). With recent improvements in pre-hospital care, including the use of advanced techniques by ambulance paramedics, the number of patients being brought to A&E departments in a potentially salvageable condition is likely to increase. These patients frequently arrive out of hours when experienced cardiothoracic or general surgeons are not immediately available (Wilson & Au, 1986). Less experienced staff are then faced with the need to perform an immediate thoracotomy but they may not have the appropriate skills to adequately perform cardiorrhaphy under extremely difficult conditions.

The use of an intracardiac latex Foley catheter as a temporary haemostatic device in this situation is well documented (Dudley, 1981; Attard, 1986). The balloon is inflated inside the heart and gentle traction is applied to the distal catheter until the balloon occludes the hole. In the acute situation, the person most able to perform this procedure may also be the one most suited to securing the airway and obtaining intravenous access in a shocked patient. Even in experienced hands, rapid venous cannulation is often difficult due to the intense venoconstriction which accompanies hypovolaemic shock and prolonged attempts may be counter-productive (Samelson *et al.*, 1987).

In our department we have used a Foley catheter for direct intracardiac fluid and drug administration as well as for haemostasis during resuscitation. To our knowledge this has not been reported in the U.K. and very little has been published elsewhere (Wilson & Au, 1986). Therefore, we decided to investigate intracardiac fluid administration using this technique in a standardized anatomical model.

MATERIALS AND METHODS

The fresh heart and lungs of a pig (Fig. 1) were obtained from the local abattoir and prepared by clamping the venous side of the circulation. A 2 cm stab wound was then made in the right ventricle, an 18 FG latex Foley catheter inserted and the balloon inflated with 10 mls of water (Fig. 2). Gentle traction was applied with artery forceps to the side arm of the catheter. A standard intravenous giving-set was connected to the Foley catheter by removing the Luer lock and inserting the rubber bung directly into the conical end of the catheter (Fig. 3). The time taken for 500 mls of normal saline to infuse passively into the ventricle from a height of

1 m was recorded. The right ventricle was sutured and the procedure repeated on the left side.

In a separate test, the flow rates through 2 Foley catheters were compared to that of 2 large bore intravenous cannulae under standardized conditions (normal saline infusion, 1 m of height, no added pressure and free drainage).

RESULTS

The average flow rate achieved into each ventricle of the anatomical model was approximately 275 ml min^{-1} (Table 2). There was no difference in the rate of flow between the ventricles. Only minimal traction on the catheter was found to be necessary to prevent leakage from the stab wound. Oozing from incisions in the lungs showed that pulmonary perfusion was obtained whilst the right ventricle was infused.

The comparison between the flow rates of the Foley catheters and the intravenous cannulae is shown in Table 3.

Fig. 1. Direct intracardiac fluid administration into pig heart and lungs using an 18 FG latex Foley catheter.

Fig. 2. Placement of haemostatic Foley catheter in right ventricular wound.

Fig. 3. Connection between Foley catheter and intravenous infusion set.

Table 2. Intracardiac infusion rates.

	Infusion rate (ml min ⁻¹)	
	Right ventricle	Left ventricle
1	259	286
2	273	275
3	288	242
4	275	288
5	275	283
Average	274	275

Table 3. Comparison of infusion rates between Foley catheters and intravenous cannulae.

	Infusion rate (ml min ⁻¹)
18FG Foley catheter	333
12G intravenous cannula	300
16FG Foley catheter	200
14G intravenous cannula	200

DISCUSSION

This study shows that large volumes of fluid can be delivered rapidly via a Foley catheter directly into the heart (Table 2). Indeed, the performance of a Foley catheter was found to compare favourably with that of large bore intravenous cannulae under similar conditions (Table 3). Wilson & Au (1986) described the infusion of 4l of Ringer's lactate and 2 units of blood into the right ventricle of a stab victim using a Foley catheter connected to a 50 ml bladder syringe. However, this technique required two members of the resuscitation team to administer and constantly monitor the procedure in order to avoid air embolism and no drugs were given. An elegant procedure for direct intracardiac infusion using the right atrial appendage has been previously described (Samelson *et al.*, 1987). For the non-specialist working in unfavourable conditions this is likely to be relatively time-consuming, it does not secure haemostasis in penetrating wounds and requires repair if resuscitation is successful.

An advantage of our technique is that the equipment required is readily available, easily assembled and present in every A&E department. Potential disadvantages of the procedure include the risk of air embolism, difficulty in controlling large wounds, the possibility of outflow obstruction and interference with internal massage. Clearly, *in vivo*, internal cardiac massage would affect the flow rate and some retrograde flow up the catheter may occur but this is not a major problem. In practice the technique is simple, quick and easily performed (Attard, 1986). Only minimal traction is required for haemostasis and air embolism can be avoided by priming the catheter with intravenous fluid prior to placement. Drugs can be easily injected through the rubber bung of the giving set.

Controversy still surrounds the use of emergency room thoractomy in chest trauma but the best results are achieved in those suffering from stab wounds (Ivatury & Rohman, 1989). Patients with penetrating cardiac injuries who survive to reach hospital are more likely to have a right ventricular injury than left (Trinkle *et al.*, 1979; Walton *et al.*, 1989). Although our procine model was purely anatomical with no attempt made to simulate physiological conditions, pulmonary perfusion was evident with the catheter placed in the right ventricle.

In conclusion, in the absence of suitable intravenous access, the technique of direct entry to the circulation via the original cardiac wound would appear to offer a rapid method for fluid and drug administration whilst securing haemostasis in a critical situation.

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