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### 1 A survey of non-depolarising muscle relaxants used in cardiac anaesthesia and surgery

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**Introduction:** Residual neuromuscular blockade contributes to postoperative morbidity and mortality, and is more common with long-acting non-depolarising muscle relaxants (NDMRs) such as pancuronium [1]. This phenomenon may be a common occurrence in 'fast-track' managed cardiac patients administered long-acting NDMRs. We examine the usage of NDMRs in cardiac anaesthesia in the United Kingdom.

**Methods:** A postal questionnaire was sent to 310 consultant cardiac anaesthetists in the United Kingdom. We asked which NDMRs are preferred (differentiating between 'fast-track' [FT] and 'non-fast-track' [NFT] management of patients), and what methods are used to assess neuromuscular function prior to extubation.

**Results:** There was a 72.6% (225/310) response rate, of which 217 responses were valid. A single-agent NDMR technique is most prevalent for both NFT (92.2%) and FT patients (88.5%). Pancuronium (either as sole agent or in combination with another NDMR) was the first choice for NFT and FT patients, 73.7% and 52.1% respectively. For both management strategies, rocuronium is the next most popular agent. Benzylisoquinolinium derivatives are not in common usage. Forty-nine out of 211 anaesthetists (where a

comparison could be made) changed their choice of NDMR between NFT and FT patients. The majority of these anaesthetists (85.7%) remove pancuronium from their practice for FT patients. Of respondents, 20.7% (45/217) indicated that an assessment of neuromuscular function was part of an extubation protocol; 75.6% (34/45) of these respondents detailed only clinical methods, whilst 6.7% (3/45) indicated use of a 'neuromuscular function monitor' alone, with 15.6% (7/45) indicating use of both methods. Amongst the responses indicating 'neuromuscular function monitor' methods, an assessment of the 'train-of-four' was the commonest response. Less than 10% monitor the neuromuscular junction during surgery.

**Conclusions:** Pancuronium remains the most popular NDMR for all types of cardiac anaesthesia. Some anaesthetists modify their choice of NDMR for FT management, changing from pancuronium to a shorter acting NDMR as the commonest adaptation. A minority of respondents indicated that a protocol exists to routinely assess the neuromuscular function prior to extubation.

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### 2 Metabolic acidosis and cardiopulmonary bypass: hypoperfusion or iatrogenic?

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**Introduction:** Many patients develop, to a varying extent, a metabolic acidosis during cardiopulmonary bypass (CPB). Often this acidosis is assumed to be the result of tissue hypoperfusion. However, fluids administered to patients before and during CPB, through their effects upon the strong ion difference (SID), may

cause metabolic acidosis [1,2]. These fluids may also produce acidosis by haemodilution because of the decrease in plasma protein concentration [2]. The aim of this study was to determine whether metabolic acidosis occurring during CPB is the result of hypoperfusion or is iatrogenic.

**Methods:** Forty-nine adult patients undergoing cardiac surgery with CPB were studied. Arterial blood was sampled before the induction of anaesthesia during the re-warming phase of CPB (35°C). Blood gas analysis and concentrations of electrolytes, plasma proteins and lactate were measured. The volumes and compositions of fluids administered were recorded.

**Results:** Factors that were found to correlate significantly ( $P < 0.05$ ) with the change in hydrogen ion concentration between the two time points were identified. Change in arterial carbon dioxide concentration was used to remove the respiratory component of acidosis. These predictor factors were then entered after change in arterial carbon dioxide tension, to first remove the respiratory component of acidosis, into a multivariate linear regression model ( $P < 0.001$ ,  $r^2 = 0.65$ ) so as to examine their influence on the change variance in hydrogen ion concentration. Only the amount of sodium bicarbonate administered ( $\beta = -0.404$ ,  $P < 0.001$ ) and the change in SID ( $\beta = -0.339$ ,  $P = 0.004$ ) were found to predict the change in hydrogen ion concentration. Change in lactate concentration ( $P = 0.072$ ) and

the total volume of fluid administered moderated by body surface area ( $P = 0.523$ ) were excluded from the model.

**Discussion:** Our sample size is underpowered to detect factors that might have a small effect size. Also, the regression model only explained 65% of the variance so factors other than those that we have identified influence the change in hydrogen ion concentration. However, our findings suggest that metabolic acidosis arising during CPB is largely induced by change in the SID and the type of fluids administered, whilst haemodilution and hypoperfusion do not appear to have important roles in its genesis. Whether this metabolic acidosis or its correction has any influence on outcome from cardiac surgery merits further research.

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### 3 An audit of re-admission to intensive care after initial recovery from pulmonary resection: is it worthwhile?

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*Critical Care* 2002, **6** (Suppl 2):3

**Objective:** To audit the outcome of patients admitted to a general intensive care unit (ICU) from a thoracic high dependency unit (HDU) after pulmonary resection.

**Methods:** A retrospective case note review of 28 consecutive patients (22 male, six female; median age, 66 years [range, 48–80 years]) admitted to the ICU following initial recovery on an HDU after pulmonary resection, in a 3-year period, in a single surgeon thoracic surgical practice.

**Results:** ICU and 6-month mortalities were 47% (13 patients) and 64% (18 patients), respectively. Need for mechanical ventilation ( $P = 0.006$ ) and subsequent renal support ( $P = 0.05$ ) were predictors of hospital mortality on multivariate analysis. All four patients who required both ventilation and renal support died. Only two of 17 patients (12%) who required mechanical ventilation were alive at 6 months ( $P = 0.002$ ). Age, sex, preoperative pulmonary function, extent of resection, diagnosis, need for reoperation and inotropic requirements were not predictors of poor outcome. Patients who died in the ICU ( $n = 13$ ) stayed for longer (mean, 17.6 days versus 5.3 days;  $P = 0.04$ ) and at a higher average cost per patient (£21,992 versus £5300;  $P = 0.04$ ) than those who survived ( $n = 15$ ).

	Hospital mortality	6-month mortality
Age		
< 70 years	47% (9 of 19)	63% (12 of 19)
> 70 years	44% (4 of 9)	67% (6 of 9)
FEV1%		
< 70% predicted	27% (3 of 11)	64% (7 of 11)
> 70% predicted	59% (10 of 17)	65% (11 of 17)
Histology		
Malignant	43% (10 of 23)	65% (15 of 23)
Benign	60% (3 of 5)	60% (3 of 5)
Mechanical ventilation		
Yes	76% (13 of 17)	88% (15 of 17)
No	0% (0 of 11)	27% (3 of 11)
Renal support required		
Yes	73% (11 of 15)	87% (13 of 15)
No	15% (2 of 13)	38% (5 of 13)

FEV1%, forced expiratory volume in 1 s as a percentage of forced vital capacity.

**Conclusions:** Mechanical ventilation for subsequent respiratory complications after initial recovery from lung resection is generally not worthwhile.

## 4 Significance of apoptosis in ischaemia and reoxygenation of the human myocardium

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Critical Care 2002, 6 (Suppl 2):4

**Background:** Apoptosis is triggered by a number of intrinsic and extrinsic factors but its importance in ischaemia–reoxygenation in the human heart is unclear. We quantified apoptosis and necrosis in an *in vitro* model of human atrial myocardium following various periods of simulated ischaemia (SI) and reoxygenation (R).

**Methods:** Experiments ( $n=8$  per group) were performed on sections of right atrium subjected to periods of SI (0, 30, 90 and 180 min) followed by R (2, 8 and 24 hours). Cell damage was measured following release of myocyte-specific creatine kinase (CK-MB) and cell viability measured using the vital stain MTT. Cell apoptosis and necrosis were visualised in tissue sections with FITC (TUNEL) and propidium iodide, respectively. Quantification was by confocal microscopy and NIH-image software. Caspase-3-like activity was quantified by fluorometric assay.

**Results:** CK-MB release and necrosis increased whereas MTT values decreased over the period of SI in a dose-dependent manner. Apoptosis increased (32%) after 90 min SI with 2 hours R and peaked (56%) after 90 min SI with 8 hours R. Apoptosis declined following 180 min R. The smallest induction of apoptosis occurred after 24 hours R. With increasing SI in the 2 hour protocol, there was a progressive rise in the ratio of caspase-3 to total caspase activity, which increased to a maximum of fourfold after 180 min SI and 2 hours R. Caspase-3 levels were similar to fresh tissue after 24 hours.

**Conclusions:** In this model of SI/R injury of human myocardium, the degree of apoptosis and necrosis varies with the duration of ischaemic insult and the reoxygenation time. After certain periods of ischaemia, apoptosis may be the predominant pathway to cell death.

## 5 Outcome following coronary artery bypass grafting in patients with non-insulin diabetes mellitus

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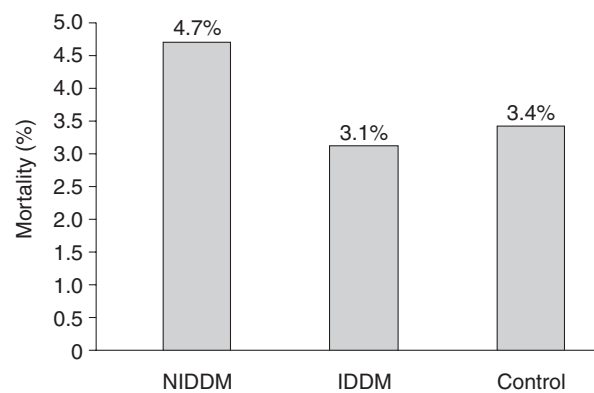
**Background:** Patients with diabetes mellitus have a worse hospital and long-term outcome after coronary artery bypass grafting (CABG) [1]. It has been shown that the non-insulin diabetes mellitus (NIDDM) group of patients on oral sulphonylureas have a higher mortality than those treated with insulin (IDDM) following myocardial infarction [2]. Oral sulphonylureas abolish ischaemic preconditioning, which is an important cardiac protective mechanism during the perioperative period of CABG [2]. Insulin resistance and hyperglycaemia decrease arterial compliance, promote plaque growth and cause contractile dysfunction of the myocytes [3].

**Objective:** To analyse retrospectively outcome data in patients with NIDDM on oral sulphonylureas who underwent CABG.

**Methods:** From a total of 2537 patients who had CABG, outcome data was identified in 236 patients with NIDDM and in 130 patients with IDDM over a 2-year period (April 1999–March 2001). We compared the mortality, length of hospital stay, length of stay in the intensive care unit (ICU), reoperation rate, ICU re-admission rate and duration of operation with control patients, matched with respect to surgeon and risk score (EuroSCORE). We also compared the incidence of diabetes in Europe and North America with Papworth.

**Results:** There was no difference in length of hospital stay, length of ICU stay, reoperation rate, ICU re-admission rate and the duration of operation.

Figure



**Conclusions:** There is a higher mortality in the NIDDM group of patients compared with the IDDM and the non-diabetic group after CABG. Intensive insulin therapy in critically ill postoperative patients showed a reduction in hospital mortality and morbidity from renal failure, blood stream infections and polyneuropathy, and reduced red cell transfusion requirement [4]. Assessment of diabetic patients in the pre-assessment clinics, stopping sulphonylureas and converting to insulin preoperatively and to tight blood glucose control perioperatively, may help improve outcome in this group of patients.

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**6 Factor VIIa for severe cardiac surgical bleeding**

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**Introduction:** Severe perioperative bleeding in cardiac surgery is multifactorial in origin. Recombinant factor VIIa (rFVIIa; Novo Nordisk, Denmark) has been used perioperatively since 1988 [1]. It promotes formation of blood clots by a range of actions. We have recently introduced it into our cardiac surgical programme for severe intractable coagulopathic bleeding.

**Purpose of study:** To assess efficacy and safety of rFVIIa in cardiac surgery by chart review.

**Methods:** Charts for the seven patients who received rFVIIa were reviewed for effects on clinical status, blood loss and transfusion need.

**Results:** Seven adult patients had received rFVIIa for severe cardiac surgical bleeding by February 2002. Five of these survived to hospital discharge. Of the two deaths, one patient died of continued haemorrhage on the operating table, and the other died at 5 days postoperation from multiple organ failure. The median total dose of rFVIIa administered was 22 µg/kg (range, 13–75 µg/kg). There were marked reductions in estimated hourly blood loss from a median 952 ml/hour (range, 182–1500 ml/hour) to a median 19 ml/hour (range, 7–41 ml/hour) after rFVIIa in the survivors. Reductions in blood product use were also noted (Table 1).

**Conclusions:** There have been two published reports on the use of rFVIIa in cardiac surgery involving one and five patients, respectively [2,3]. In this review, we have found that five out of seven

**Table 1**

**Median units of blood product used for the five surviving patients (range)**

Product	Before Novo7	After Novo7
Fresh frozen plasma	2 (0–12)	0
Platelets	2 (2–4)	0 (0–3)
Cryoprecipitate	10 (0–10)	0
Beriplex	1000 (0–1000)	0

patients all with severe perioperative bleeding appeared to benefit from the administration of rFVIIa. There were no thrombotic complications noted. Further research into the optimal role for rFVIIa in cardiac surgery is justified.

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**7 A comparison of rocuronium and pancuronium in adult patients scheduled for ‘fast-track’ elective open heart surgery involving hypothermic cardiopulmonary bypass**

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*Critical Care* 2002, **6** (Suppl 2):7

**Introduction:** The non-depolarising muscle relaxant (NDMR) pancuronium continues to be used for fast-track cardiac anaesthesia despite its declining popularity elsewhere. Its duration of action can be unpredictable and prolonged, leading to an increased incidence of residual neuromuscular block [1]. We examined whether pancuronium remains an appropriate NDMR for ‘fast-track’ patients and include comparison with rocuronium, which has been suggested as an alternative agent.

**Methods:** Twenty patients eligible for ‘fast-track’ cardiac surgery were prospectively randomised to receive either pancuronium 0.1 mg/kg or rocuronium 1 mg/kg in a double-blind study design. Neuro-muscular function was assessed by acceleromyography and the time to recovery of train-of-four (TOF) ratio of 0.9 was measured. A standardised anaesthetic technique was employed which avoided the use of volatile anaesthetic gases and vapours.

**Results:** Both groups had similar demographic makeup and were well matched for confounding variables. No patient required supplementary doses of NDMR.

The median times (in minutes) for pancuronium and rocuronium, respectively, to recovery of TOF 0.9 were 472.5 (SD, 103.7) and 217.5 (SD, 56.6). The observed difference in TOF 0.9 medians was 255 (95% CI, 150–320). The Mann–Whitney test was highly significant at  $P=0.0003$ .

No patient in the rocuronium group and 7/10 patients in the pancuronium group had their extubations delayed as a consequence of residual paralysis.

**Conclusions:** We have demonstrated that pancuronium lasts approximately twice as long and has approximately double the inter-individual variation compared with rocuronium. We recommend that pancuronium is no longer an acceptable NDMR in such patients. Although rocuronium has potential as an alternative agent, we recommend that due to variation in its duration of action post-hypothermic cardiopulmonary bypass, patients should routinely have their neuro-muscular function monitored prior to extubation.

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## 8 Substernal epicardial echocardiography in a patient undergoing left ventricular assist device: a case report

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A 59-year-old patient undergoing placement of a left ventricular assist device had a substernal epicardial echocardiography imaging technology device inserted intraoperatively. This was used postoperatively in the intensive care unit to optimise the patient's haemodynamic status and facilitate weaning from an intra-aortic balloon pump and inotropic support.

Substernal epicardial echocardiography (SEE) is a new echocardiography technique [1]. This is a modified chest drainage tube with a dual lumen creating an insertion pathway accommodating a transoesophageal echo (TOE) probe, while also acting as a mediastinal chest drain tube. The TOE probe lies within a blind-ended 'sock' along the underside of the chest drain. The device is placed in an anterior epicardial position prior to closure of the sternum, and allows the subsequent insertion of a standard TOE probe, allowing post-operative echocardiographic imaging of the heart. The chest tube sock permits rotational and vertical manipulation of the TOE probe.

We present the images obtained with the SEE and concur with a previous study that the quality of the images shown is excellent [2].

We conclude that this novel echo mode can be used serially in the intensive care unit to accurately assist in the assessment of ventricular function and filling during weaning of an intra-aortic balloon pump and inotropic drugs.

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