Contribution of muscle relaxant to the haemodynamic course of high-dose fentanyl anaesthesia: a comparison of pancuronium, vecuronium and atracurium

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To define the role of muscle relaxants in haemodynamic responses to high-dose (75 $\mu g \cdot kg^{-1}$) fentanyl anaesthesia and to noxius stimuli associated with intubation and sternal spread during coronary artery bypass surgery, we compared haemodynamics between three groups of patients given either pancuronium (0.1 $mg \cdot kg^{-1}$, n = 11), vecuronium (0.086 $mg \cdot kg^{-1}$, n = 11) or atracurium (0.43 $mg \cdot kg^{-1}$, n = 12). Additional doses of the relaxants were given to maintain a 90 per cent neuromuscular block. Patients given pancuronium showed no increases in mean values of heart rate, arterial pressure or cardiac output during the induction of anaesthesia or after intubation, whereas a decrease in these variables was observed in the vecuronium group. The haemodynamics in the atracurium group were intermediate compared with the other two study groups. In spite of a decrease in coronary perfusion pressure, no patient given vecuronium developed myocardial ischaemia. An advantage of vecuronium over pancuronium and atracurium was an attenuation of the blood pressure response to sternotomy. Patients given atracurium had a small increase in pulmonary vascular resistance during sternotomy. Our patients continued their beta-adrenergic antagonist medication until the morning of the day of operation and they were pretreated with a small intravenous dose of diazepam (0.1 $mg \cdot kg^{-1}$) before induction of anaesthesia. These drugs may have prevented the deleterious haemodynamic effects observed by some investigators after the administration of pancuronium during high-dose fentanyl anaesthesia.

Key words

NEUROMUSCULAR RELAXANTS: pancuronium, vecuronium, atracurium; ANAESTHETICS, intravenous: fentanyl; ANAESTHESIA; cardiovascular.

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Pancuronium has been widely used as a muscle relaxant during high-dose fentanyl anaesthesia for cardiac surgery. The rationale for this practice is that the vagolytic and sympathomimetic effects of pancuronium tend to antagonise the vagally mediated bradycardia resulting from fentanyl administration.[1] However, in some patients the heart rate accelerating effect of pancuronium may exceed the bradycardic effect of fentanyl.[1,2] Furthermore, pancuronium may also exaggerate circulatory responses to noxius stimuli.[3] Since these properties of pancuronium may be harmful in patients with limited coronary vascular reserve, studies have been done to find out whether another neuromuscular blocking drug or drug combination might prove safer for these patients.[2,4–6]

Vecuronium and atracurium are new muscle

relaxants without vagolytic and sympathomimetic effects (the absence of the latter effect in the case of atracurium is, however, not well documented).[7–11] Like pancuronium, vecuronium does not release histamine.[12] Atracurium does cause release of histamine but in amounts less than those produced by metocurine or tubocurarine.[13] Thus, vecuronium and atracurium should be potentially useful muscle relaxants for cardiac patients.

In our previous study, pancuronium did not accelerate heart rate over the awake control level but only reversed the decrease in heart rate and cardiac output caused by fentanyl, whereas vecuronium further decreased these parameters.[6] In that study, succinylcholine was administered for intubation, and pancuronium or vecuronium was administered later. It is therefore possible that the haemodynamic effects of pancuronium and vecuronium were modified by the effect of succinylcholine on the autonomic nervous system[14] or by the delay of the administration of the nondepolarising relaxant. The present study differs from the previous one in that the nondepolarising relaxant was given before intubation and a patient group receiving atracurium was included.

Methods

Patients

Thirty-four patients scheduled for elective coronary artery bypass grafting (CABG) were studied. We excluded patients with significant valvular disease, those with critical narrowing of the left main coronary artery, and patients with ejection fraction < 0.40, as estimated by cineangiocardiography. The patients were randomly allocated to three groups, receiving either pancuronium, vecuronium or atracurium in a blind fashion. Beta-adrenergic blocking drugs and calcium entry blockers were continued up to the morning of the operation day. The patients gave their consent to the study, which had been approved by the Ethical Committee of the institute.

Anaesthesia

On the evening before operation the patients were given pentobarbitone 100–200 mg and promethazine 25–50 mg orally. As premedication all patients received $0.2\ mg \cdot kg^{-1}$ morphine and $0.006\ mg \cdot kg^{-1}$ scopolamine intramuscularly. On arrival in the operating theatre, an intravenous infusion of Ringer's acetate solution was started and $0.1\ mg \cdot kg^{-1}$ of diazepam was given intravenously in divided doses. During preparation of the monitoring, patients received $10\ ml \cdot kg^{-1}$ of Ringer's acetate and thereafter a constant infusion of $2\ ml \cdot kg^{-1} \cdot h^{-1}$. Radial arterial and triple-lumen pulmonary arterial catheters were inserted under local anaesthesia (one per cent lidocaine). During the preparation for anaesthesia the patients were given 35 per cent oxygen via a venturi mask.

Anaesthesia was induced with fentanyl at a rate of $7.5\ \mu g \cdot kg^{-1} \cdot min^{-1}$ to a total dose of $75\ \mu g \cdot kg^{-1}$. Three minutes after the start of the fentanyl infusion, a bolus dose of either pancuronium $0.1\ mg \cdot kg^{-1}$, vecuronium $0.086\ mg \cdot kg^{-1}$ or atracurium $0.43\ mg \cdot kg^{-1}$ was given intravenously from a blinded syringe. Seven minutes after the administration of the muscle relaxant, the larynx and trachea were sprayed with four per cent lidocaine, 2 ml, and the trachea was intubated.

Ventilation was first assisted or controlled manually with 100 per cent oxygen using a nonrebreathing valve and, after intubation, controlled with a mixture of oxygen and air (FiO_2 0.50) using the nonrebreathing circuit of a Servo 900 B ventilator. Respiratory rate was 12 $breaths \cdot min^{-1}$ and the tidal volume was adjusted to maintain $PaCO_2$ at a normal level.

The degree of neuromuscular block was estimated using supramaximal ulnar nerve stimulation and quantitation of the evoked electromyographic response (NT-monitor, Organon). A neuromuscular block of at least 90 per cent was maintained by giving one-fifth of the initial dose of the relaxant when needed.

Study design and measurements

Systemic arterial pressure, pulmonary arterial pressure, central venous pressure and the V_5 lead of the ECG were recorded throughout the study. More detailed haemodynamic measurements were made at the following times: (1) Five to ten minutes after the insertion of the vascular catheters. (2) Two minutes after the administration of the muscle relaxant. (3) Seven minutes after the administration of the muscle relaxant, immediately before intubation. (4) Immediately after intubation. (5) Before the start of surgery. (6) After sternal spread.

Haemodynamic measurements included heart

TABLE I Preoperative data

	Pancuronium	*Atracurium*	*Vecuronium*
N (female/male)	1/10	0/12	1/10
Age (yr)	53.3 ± 6.5	53.0 ± 7.8	55.2 ± 8.2
Weight (kg)	76.6 ± 7.6	81.6 ± 7.1	82.6 ± 9.9
BSA (m^2)	1.85 ± 0.1	1.95 ± 0.1	1.97 ± 0.1
Previous myocardial infarction	9	7	5
β-adrenergic blocking drug	9	10	11
Calcium-entry blocker	4	7	6
Digoxin	1	2	2
Ejection fraction	0.59 ± 0.11	0.57 ± 0.97	0.60 ± 0.08
Dyssynergy	5	3	2

Number of patients or mean values ± SD.

rate (HR), systolic, diastolic and mean arterial pressure (SAP, DAP, MAP), mean pulmonary arterial pressure (MPAP), mean pulmonary capillary wedge pressure (PCWP), mean central venous pressure (CVP) and cardiac output (CO). All pressures were measured with appropriate transducers zeroed to the midthoracic line and recorded with an ink-jet recorder. Mean pressures were transduced electronically and all pressures read at end-expiration. Cardiac output was measured with thermodilution using 0.9 per cent saline at room temperature and expressed as the mean of the values calculated from three well-formed curves. The following haemodynamic parameters were calculated using standard formulae: cardiac index (CI), stroke index (SI), systemic and pulmonary vascular resistances (SVR, PVR), rate–pressure product (RPP) and coronary perfusion pressure (CPP = DAP–PCWP).

Before opening the code of treatment, three investigators evaluated separately the ECG recordings for evidence of myocardial ischaemia. This was diagnosed when a new ST-segment depression ⩾ 1 mm was observed at a calibration of 10 mm/mV in lead V_5. The ST-segment was evaluated with respect to the PQ junction at a point 80 ms following the S-wave nadir.

TABLE II Arterial PCO_2 (mmHg)

	Pancuronium	*Atracurium*	*Vecuronium*
Control	40 ± 3	39 ± 3	39 ± 5
Preintubation	45 ± 6	44 ± 5	40 ± 5
Presurgery	38 ± 4	37 ± 3	37 ± 3

Mean values ± SD.

Statistical methods

Repeated measurements analysis of variance (BMDP program 8v)[15] was used to assess the significance of the changes over time and of the differences between the three groups. To supplement the analysis of variance, the t-test for paired data was applied to assess the significance of the changes from the control values within the groups and the t-test for unpaired data was used to compare changes between the groups. The Bonferroni allowance was used to correct for multiple pairwise testing. Fisher's exact test was applied to the frequency data to compute the exact two-tailed probabilities of observing the results due to chance, given the marginal totals.

Results

The three groups of patients were comparable with respect to preoperative characteristics (Tables I and III). Table II presents the arterial PCO_2 values; the groups did not differ significantly with respect to this variable. Additional doses of the relaxants were given as follows: one dose of pancuronium, six patients; one–two doses of vecuronium, six patients; two–five doses of atracurium, 11 patients.

Table III and the Figure summarize the haemodynamic data. When the changes from the awake control values observed at various study periods were compared between the groups, the only significant difference between the pancuronium and atracurium groups was the greater PVR in the latter group after sternal spread. By contrast, comparison between the pancuronium and vecuronium groups revealed significant differences in HR, CI, MAP, RPP and CPP, the patients given vecuronium showing lower values in these variables than those

TABLE III Haemodynamic variables

	Awake	*During induction*	*Before intubation*	*After intubation*	*Before incision*	*Sternal spread*
HR (beats·min^{-1})						
Pancuronium	62.4 ± 11.9	62.4 ± 7.0	65.9 ± 6.9	65.3 ± 6.7	55.5 ± 6.8	60.4 ± 12.6
Atracurium	62.1 ± 6.6	60.1 ± 6.2	59.5 ± 6.8	57.6 ± 7.5	49.6 ± 5.2‡	55.6 ± 14.6
Vecuronium	61.1 ± 7.5	56.0 ± 7.5	55.5 ± 6.2* PV*	53.5 ± 6.3† PV*	47.3 ± 5.0‡	49.2 ± 4.9‡
CI (L·min^{-1}·m^{-2})						
Pancuronium	3.35 ± 0.72	3.21 ± 0.73	3.53 ± 0.56	3.54 ± 0.62	2.61 ± 0.57†	2.94 ± 0.78
Atracurium	2.99 ± 0.56	2.77 ± 0.42	3.00 ± 0.64	2.75 ± 0.54	2.01 ± 0.20‡	2.39 ± 0.82
Vecuronium	3.07 ± 0.58	2.77 ± 0.61	2.81 ± 0.70	2.54 ± 0.55‡ PV*	2.07 ± 0.54‡	2.27 ± 0.62‡
SI (ml·m^{-2})						
Pancuronium	54 ± 10	51 ± 8	55 ± 7	54 ± 8	47 ± 9	49 ± 11
Atracurium	48 ± 9	46 ± 9	50 ± 9	48 ± 9	41 ± 7	43 ± 8
Vecuronium	50 ± 7	50 ± 13	51 ± 12	48 ± 10	44 ± 12*	46 ± 9
MAP (mmHg)						
Pancuronium	87 ± 13	77 ± 24	83 ± 20	86 ± 16	89 ± 13	113 ± 14†
Atracurium	91 ± 10	78 ± 18	83 ± 19	87 ± 17	81 ± 15	116 ± 23†
Vecuronium	95 ± 11	70 ± 9‡ PV*	73 ± 11‡	79 ± 11†	71 ± 12† PV†	97 ± 16 PV* AV*
MPAP (mmHg)						
Pancuronium	17.5 ± 4.3	16.8 ± 3.8	16.5 ± 3.2	17.0 ± 3.4	15.0 ± 2.6	17.4 ± 3.9
Atracurium	19.7 ± 3.6	17.9 ± 3.8	18.2 ± 4.8	18.8 ± 4.3	15.3 ± 3.0	20.5 ± 4.3
Vecuronium	17.6 ± 4.0	15.5 ± 3.8	14.7 ± 4.5	15.0 ± 3.8	13.6 ± 3.9	16.6 ± 5.2
PCWP (mmHg)						
Pancuronium	11.4 ± 3.7	11.5 ± 3.6	11.5 ± 2.9	10.5 ± 2.3	9.8 ± 2.4	11.7 ± 2.8
Atracurium	14.2 ± 3.5	13.4 ± 3.5	13.3 ± 4.2	13.6 ± 3.5	10.7 ± 2.3†	13.6 ± 3.4
Vecuronium	11.2 ± 3.5	10.3 ± 3.1	10.2 ± 3.3	9.8 ± 2.9	9.1 ± 2.0	12.1 ± 5.2
CVP (mmHg)						
Pancuronium	6.0 ± 2.5	6.5 ± 2.0	5.8 ± 1.9	5.9 ± 1.6	5.6 ± 1.2	6.6 ± 1.9
Atracurium	8.2 ± 2.7	8.3 ± 2.7	7.6 ± 2.7	8.8 ± 1.9	6.9 ± 2.2	7.8 ± 2.0
Vecuronium	6.0 ± 3.2	6.1 ± 2.8	5.8 ± 2.7	6.3 ± 2.2	6.1 ± 2.5	6.1 ± 2.7
RPP (mmHg·beats·min^{-1}·10^{-3})						
Pancuronium	7.98 ± 2.41	6.90 ± 2.23	7.86 ± 1.99	8.08 ± 2.11	6.90 ± 1.18	9.34 ± 2.40
Atracurium	8.41 ± 1.50	6.97 ± 1.61	7.16 ± 1.38	7.33 ± 1.32	5.70 ± 1.10†	9.29 ± 4.76
Vecuronium	8.18 ± 1.30	5.72 ± 1.00‡	5.91 ± 0.91‡	6.15 ± 1.34‡	4.86 ± 1.02‡ PV*	6.57 ± 1.35† PV†
CPP (mmHg)						
Pancuronium	51 ± 9	43 ± 16	49 ± 13	53 ± 11	56 ± 10	72 ± 12‡
Atracurium	52 ± 7	43 ± 15	47 ± 13	46 ± 14	49 ± 11	71 ± 18†
Vecuronium	54 ± 7	38 ± 8†	42 ± 7†	46 ± 9	43 ± 10 PV†	59 ± 7 PV* AV*
SVR (dyn·s·cm^{-5})						
Pancuronium	1093 ± 263	976 ± 380	962 ± 250	999 ± 218	1462 ± 481	1653 ± 393†
Atracurium	1176 ± 276	1071 ± 373	1086 ± 374	1208 ± 360	1518 ± 274*	2000 ± 685†
Vecuronium	1216 ± 266	999 ± 312	1015 ± 258	1191 ± 225	1342 ± 379	1713 ± 426†
PVR (dyn·s·cm^{-5})						
Pancuronium	80 ± 22	71 ± 17	62 ± 17	81 ± 27	88 ± 28	84 ± 35
Atracurium	79 ± 36	69 ± 35	71 ± 38	80 ± 34	94 ± 36*	126 ± 45†
Vecuronium	85 ± 33	79 ± 25	67 ± 27	84 ± 23	90 ± 37	87 ± 41 PA* AV*

*$p < 0.05$, †$p < 0.01$, ‡$p < 0.001$. Significant changes within the groups and significant differences between the groups are shown.
PV = pancuronium vs vecuronium. PA = pancuronium vs atracurium. AV = atracurium vs vecuronium.
Mean values ± SD.

receiving pancuronium. The significant differences in HR and CI were observed at the time of intubation, whereas those in MAP, RPP and CPP occurred mainly in the pre- and poststernotomy periods. After sternal spread, the atracurium group had higher MAP, PVR and CPP than the vecuronium group.

Even the pancuronium group showed no obvious haemodynamic response to endotracheal intubation, the intergroup difference in HR and CI resulting mainly from the decreased values in the vecuronium group. After sternal spread, the average MAP was significantly increased in the pancuronium and atracurium groups but reached only the control level in the vecuronium group. This increase in MAP was due to an elevation of SVR.

The incidences of notable haemodynamic changes are presented in Table IV. There were significant differences between the pancuronium and vecuronium groups in the incidence of marked bradycardia (HR < 45 beats·min^{-1}) and in the incidence of HR exceeding the control value by 10 beats·min^{-1}. A decrease in systolic arterial pressure necessitating treatment with ephendrine (< 80 mmHg) was observed in one patient and he had received pancuronium. Flushing was not seen in any of the patients.

Five patients showed significant (0.1–0.15 mV) ST-segment depression during the awake control stage, but these ECG findings remained unchanged during the later study periods. New electrocardiographic changes of myocardial ischaemia were noted in two patients receiving pancuronium and in two given atracurium. One patient of the pancuronium group and another of the atracurium group showed ST-segment depression after sternotomy. The former patient had an increase in HR from the control value of 78 to 96 beats·min^{-1} and the latter from 62 to 100 beats·min^{-1}. In the other two patients, ST-segment depression occurred after the administration of the muscle relaxant. In the patient receiving pancuronium, HR was decreased and in the patient receiving atracurium, HR increased only slightly. However, both these patients experienced a decrease in CPP (P: from 55 to 40 mmHg; A: from 51 to 38 mmHg).

Discussion

In our pancuronium group, no changes were observed in the mean values of HR, MAP or any other

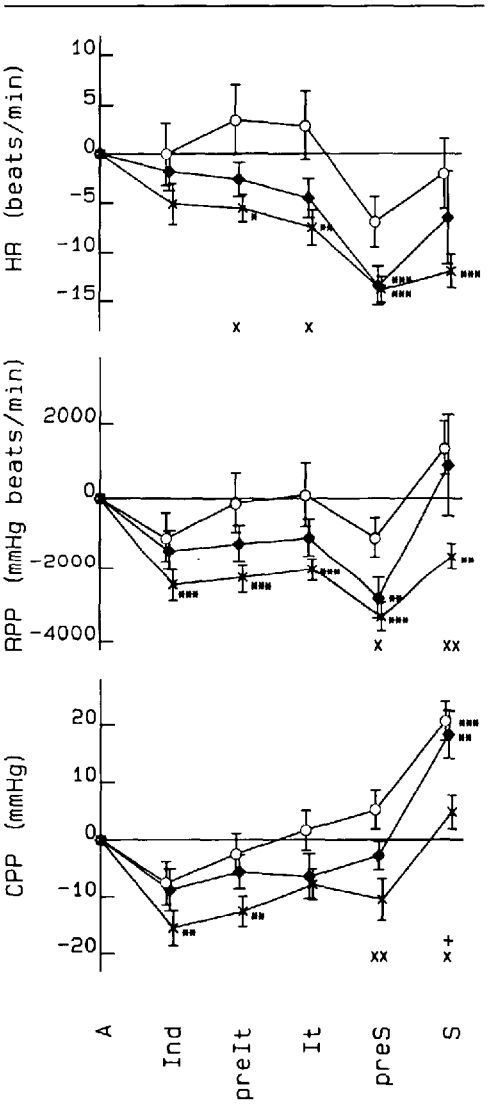

FIGURE Changes from the awake control values of heart rate, rate-pressure product and coronary perfusion pressure induced by pancuronium (○), atracurium (◆) and vecuronium (×) during high-dose fentanyl anaesthesia. A = awake control, Ind = during induction of anaesthesia, preIt = before intubation, It = after intubation, preS = before the start of surgery, S = after sternal spread. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; significant change within the group. ×, $p < 0.05$; ××, $p < 0.01$; significant difference between pancuronium and vecuronium groups. +, $p < 0.05$; significant difference between atracurium and vecuronium groups.

TABLE IV Incidence of ST-segment depression and important haemodynamic changes

	Pancuronium $n = 11$	*Atracurium* $n = 12$	*Vecuronium* $n = 11$
ST-segment depression ≥ 0.1 mV	2	2	0
HR < 45 beats·min^{-1}	0	2	5*
HR > control + 10 beats·min^{-1}	5	1	0*
HR > control + 20 beats·min^{-1}	1	1	0
SAP < 90 mmHg	4	2	3
SAP > 160 mmHg	3	5	2
RPP > 10000 mmHg·beats·min^{-1}	4	3	0

*$p = 0.035$; pancuronium vs vecuronium.

haemodynamic variable after the administration of the relaxant or after intubation. These findings are in agreement with those of others who have studied similar patients during high-dose fentanyl anaesthesia.[16–18] However, others have reported an increase in HR after the administration of pancuronium[2,19,20] or significant haemodynamic responses to intubation.[19] In all these studies the dose of fentanyl was about the same and there were no great differences between the patient populations studied. However, in the studies in which an increase in HR was observed, either the beta-blockers were withheld from the night prior to surgery[19,20] or diazepam was not given before fentanyl.[2] Diazepam in doses as small as used in the present study has been shown to convert the small increase in plasma catecholamines seen during induction of fentanyl-metocurine anaesthesia into a decrease and to significantly affect the haemodynamic course of the anaesthetic induction.[21]

The post-relaxant haemodynamics of the present study are broadly comparable to those of our previous study in which pancuronium or vecuronium was administered after the patients had recovered from succinylcholine-induced neuromuscular block.[6] It is therefore probable that succinylcholine does not significantly modify haemodynamic responses to pancuronium or vecuronium during high-dose fentanyl anaesthesia preceded by intravenous diazepam.

As in our pancuronium group, we found no significant changes in the mean haemodynamic values of our atracurium group after the administration of the relaxant and after intubation. Furthermore, the incidences of hypotension and tachycardia were not greater in the atracurium group than in the other study groups and flushing was not observed in any of the patients receiving atracurium. These haemodynamic findings are in agreement with those of Starr *et al.*,[22] who gave a similar dose of atracurium during high-dose fentanyl anaesthesia. However, Skourtis *et al.*[23] reported a significant decrease in MAP and SVR after a bolus dose of 0.35 mg·kg^{-1} of atracurium during high-dose fentanyl anaesthesia although a dose of 0.3 mg·kg^{-1} did not produce any haemodynamic changes. In addition, in another study, one of the 16 patients with coronary artery disease exhibited a typical circulatory histamine response after a bolus dose of 0.3 mg·kg^{-1} of atracurium during lorazepam-N_2O-fentanyl anaesthesia.[24] Almost all patients of our atracurium group required an additional dose of the relaxant before sternotomy. It is, however, uncertain whether the small increase in PVR observed in our patients at the time of sternotomy is due to histamine release. There is some evidence that it is the size of the bolus dose of atracurium and not the total dose that will determine the occurrence of haemodynamic changes.[23] Although we found no clinical signs of histamine release after a rapid injection of a dose of atracurium permitting intubation, it is probably wise to inject such doses slowly in order to avoid histamine-induced circulatory changes in occasional patients.[25] Perhaps the administration of the H_1 antagonist promethazine on the evening before surgery may have influenced the haemodynamic response to atracurium in this study.

The differences in HR, CI and MAP between our vecuronium and pancuronium groups may be explained by the vagolytic and sympathomimetic effects of pancuronium which tended to counteract the depressing effect of fentanyl on these variables.[6] In addition, our previous results suggest that vecuronium might have a moderate negative chrono-

tropic effect.[6] However, no change in HR after vecuronium was observed in some other studies made in patients undergoing CABG under high-dose fentanyl[22,26] or halothane anaesthesia.[5] In the present study, the incidence of marked bradycardia (HR < 45 beats·min^{-1}) was about the same as in our previous study;[6] however, sinus rhythm was maintained in all patients in these studies after vecuronium. An advantage of vecuronium over pancuronium and atracurium was the attenuation of blood pressure response to sternotomy.

The incidence of myocardial ischaemia before surgery was somewhat smaller in our patient groups (P 1/11; A 1/12; V 0/11) than that recently reported by Thomson and Putnins[2] in a patient group given pancuronium during the induction of high-dose fentanyl anaesthesia (3/12). Furthermore, in our patients ischaemia before surgery was not associated with an increase in HR and RPP, as was the case in Thomson's patients, but might rather be due to a decrease in CPP. However, no patient given vecuronium developed myocardial ischaemia despite a decrease in CPP during the induction of anaesthesia. In addition, no patient of the vecuronium group showed tachycardia or ST-segment depression during sternotomy. Larger patient groups are obviously needed to find out whether there is a real difference in the incidence of myocardial ischaemia between patients receiving various muscle relaxants.

The doses of the muscle relaxants used in the present study were calculated from the dose response curves obtained by Gramstad and Lilleaasen[27] who used a cumulative dose regimen. Although a single bolus dose technique is obviously preferable for determining potency for relatively short-acting drugs like vecuronium and atracurium,[28] the potency ratios obtained with these two methods do not seem to differ significantly.[29]

In summary, when administered during high-dose fentanyl anaesthesia in patients under beta-adrenergic blockade and pretreated with iv diazepam, pancuronium did not produce increases in heart rate, arterial pressure or cardiac output, whereas patients given vecuronium showed a decrease in these variables. The haemodynamic effects of atracurium were intermediate compared with the other two relaxants. In spite of a decrease in coronary perfusion pressure no patient given vecuronium developed myocardial ischaemia. An advantage of vecuronium over pancuronium and atracurium was an attenuation of the haemodynamic response to sternotomy.

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Résumé

Afin de définir le rôle des relaxants musculaires dans les réponses hémodynamiques aux hautes doses (75 $\mu g \cdot kg^{-1}$) de fentanyl et à la stimulation associée à l'intubation et l'écartement sternal durant la chirurgie pour pontage aortocoronarien, on a comparé l'hémodynamie entre trois groupes de patients ayant reçu soit du pancuronium (0.1 $mg \cdot kg^{-1}$, n = 11), soit du vecuronium (0.086 $mg \cdot kg^{-1}$, n = 11), soit l'atracurium (0.43 $mg \cdot kg^{-1}$), n = 12). Des doses additionnelles de relaxants musculaires ont été données afin de maintenir le bloc neuromusculaire à 90 pour cent. Les patients ayant reçu du pancuronium n'ont pas démontré une augmentation dans les valeurs moyennes de la fréquence cardiaque, la pression artérielle ou le débit cardiaque lors de l'induction de l'anesthésie et après intubation. Ces variables cependant ont diminué chez le groupe ayant reçu du vecuronium. Pour le groupe atracurium, les valeurs hémodynamiques ont été intermédiaires comparativement aux deux autres groupes étudiés. Malgré une diminution de la pression de perfusion coronarienne, aucun patient ayant reçu du vecuronium n'a développé de l'ischémie myocardique. Comparativement au pancuronium et l'atracurium, l'avantage du vecuronium était représenté par une atténuation de la tension artérielle en réponse à la sternotomie. Les patients ayant reçu de l'atracurium ont présenté une augmentation minime de la résistance vasculaire pulmonaire lors de la sternotomie. Nos patients ont continué leur médication habituelle aux antagonistes bêta-adrénergiques jusqu'au matin de l'opération et ont reçu une petite dose intraveineuse de diazepam (0.1 $mg \cdot kg^{-1}$) avant l'induction de l'anesthésie. Ces médicaments peuvent avoir prévenu les effets hémodynamiques néfastes observés par d'autres investigateurs après l'administration du pancuronium lors de l'anesthésie au fentanyl à haute dose.