suction catheter, size 12 or 14 French, which must be at least 50 cm long to extend past the tip of the endotracheal tube.

At the end of surgery, particularly after maxillo-facial procedures, the nasotracheal assembly was left in place until the trachea could be extubated safely. For prolonged endotracheal intubations, a T-piece arrangement was attached to supply humidified oxygen enriched air. In some cases the tube was left in place for up to 48 hours; spontaneously breathing, conscious patients seemed to breathe quite comfortably with it. With the relatively small endotracheal tube and the connecting tube of about equal size, we have not observed adverse effects due to pressure exerted at the nasal alae or inside the nasal passages.

Discussion

Nasotracheal intubation is the preferred approach to airway control for oral and maxillo-facial surgery and for plastic surgery about the lower part of the face.

The described extension of the nasotracheal tube by a nylon embedded latex tube combined with our lightweight coaxial breathing circuit provides for a flexible anesthetic system that can be incorporated readily into various surgical drapes. It offers virtually unimpeded access to the surgical field, while permitting the anesthetist to have access to the connection between nasotracheal tube and breathing circuit without disturbing the surgical field.

The nearly doubling in length of an airway of narrow diameter gives rise to concern about airway resistance. Although our measurement (fig. 3) may be considered near the limit of acceptability, we have found all the postoperative patients awake and breathing spontaneously, quite comfortable with this tube in place. Recent studies by Moote *et al.* in our Department, demonstrated that patients breathing spontaneously under anesthesia adapt readily to considerably greater loads.[7]

There may be concern about the connection between the latex tube and the plastic tracheal tube, which is hidden inside the nasal passage. The 35-mm long latex sleeve makes a disconnection due to pull impossible. Kinking of the uninforced latex portion of the connecting tube would be a potential hazard. We have not yet encountered this problem, always taking care that the plastic tube is advanced into the latex sleeve until it touches the reinforcing nylon spiral. The connection should be tested for kinking before insertion.

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Anesthesiology
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Hemodynamic Response to Diazepam: Dependence on Prior Left Ventricular End-diastolic Pressure

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Diazepam has a relatively safe cardiovascular (CV) record. Circulatory stability usually is maintained after intravenous diazepam.[1] Yet, occasionally substantial decreases in blood pressure (BP) and cardiac output have been reported,[2] and significant CV depression has been observed when diazepam is used in association with narcotics.[3] Since diazepam also is known to decrease left

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ventricular end-diastolic pressure (LVEDP),[4] we investigated whether patients with elevated LVEDP at the moment of cardiac catheterization ($LVEDP_{cath}$) had, upon induction of anesthesia with diazepam, a different hemodynamic response from patients with normal $LVEDP_{cath}$.

Materials and Methods

Eighteen consenting patients, averaging 56.6 ± 5.2 yr (mean ± SD) and scheduled for coronary artery bypass graft (CABG) following left cardiac catheterization, were studied early on the morning of surgery. The time interval between cardiac catheterization and study was 2 to 3 weeks. Except for one patient in Group 2 who was started on digoxin after cardiac catheterization, the therapeutic regimens of the other patients remained unchanged after catheterization. Nine patients had an $LVEDP_{cath}$ below 15 mmHg (Group 1), and nine had $LVEDP_{cath}$ equal to or higher than 15 mmHg (Group 2). $LVEDP_{cath}$ was obtained by averaging the LVEDP values of four to five separate beats recorded prior to ventriculography. Ejection fractions, assessed from single-plane cineangiograms, were 0.63 ± 0.08 in Group 1 and 0.38 ± 0.12 in Group 2 ($P < 0.001$). Demographic data and information regarding cardioactive drugs, number of grafts, and left ventricular kinetics are listed in Table 1. Overall hypokinesia was described as mild in Group 1 and moderate to severe in Group 2.

Cardioactive drugs were discontinued on the morning of surgery. Secobarbital (2 mg/kg) was given im 1 h prior to induction of anesthesia. After an intravenous infusion of 5% dextrose in lactated Ringer's solution was started, a 20-gauge angiocath was introduced in the left radial artery to monitor blood pressure and arterial blood gases (ABG). Systolic time intervals (STI) were detected online by external electrophonomechanography and measured by automated processing of the analog signals as described elsewhere.[5] Minute-by-minute averages were obtained for heart rate (HR), systolic (SBP) and diastolic (DBP) blood pressure, preejection period (PEP), left ventricular ejection period (LVET), total electromechanical systole (TEMS), and the PEP/LVET ratio.

After blood samples for ABG analyses were taken, the patients breathed 100% O_2 by mask for 3 min. Then an initial dose of 30 μg/kg of diazepam (D_1) was injected, rapidly followed, at 5 min, by 30 μg/kg (D_2) and at 10 min by 60 μg/kg (D_3). Ventilation was spontaneous for the first 10 min but was assisted for the last 5. At minute 16, a second ABG sample was obtained. At that time, about 350 ml of 5% dextrose in lactated Ringer's solution had been infused. Subsequently, further deepening of anesthesia and muscle relaxation were secured by appropriate doses of fentanyl and pancuronium. Hemodynamic data obtained at 1 min before the injection of D_1 (baseline = B) and at the 5th min after D_1, D_2, and D_3 were used for statistical analyses, which included analyses of variance and covariance with repeated measures (BMD p2V package), the Newman–Keuls test, and simple linear regression analysis.

TABLE 1. Demographic and Cardiac Information

		Group 1	Group 2
Sex		9/9 male	8/9 male
Age (yr)		56.6 ± 5.2	58.4 ± 7.1
$LVEDP_{cath}$ (mmHg)		9 ± 4	20 ± 3
Patients with	Single CABG	1	1
	Double CABG	1	0
	Triple CABG	7	8
Patients receiving cardioactive drugs	Propranolol	8/9	6/9
	Nitroglycerine	3/9	5/9
	Isosorbide dinitrate	2/9	2/9
	Digoxin	1/9	4/9
Patients with left ventricular hypokinesia	Inferior	5/9	1/9
	Anterior		3/9
	Generalized	1/9	3/9
Patients with left ventricular aneurysm	Anterior		2/9

Values ± = mean ± SD.

Results

At the moment of cardiac catheterization, the mean LVEDP of Group 1 was 9 ± 4 mmHg and 20 ± 3 mmHg in Group 2. At baseline, no differences in CV variables were observed between the groups (table 2). The overall dose-related response of the monitored hemodynamic variables to cumulative doses of diazepam was not significant in Group 1. In Group 2 the responses of SBP ($P < 0.005$), DBP ($P < 0.005$), PEP ($P < 0.005$), and the ratio PEP/LVET ($P < 0.05$) were significant. More specifically in Group 2, after D_1, SBP (−13 ± 13 mmHg, $P < 0.01$) and DBP (−4 ± 5 mmHg, $P < 0.05$) decreased while PEP (5 ± 4 ms, $P < 0.01$) increased. Although D_2 did not induce any further statistically significant hemodynamic changes, the trends continued such that D_3 caused further significant decreases of SBP and DBP. After D_3, SBP was lower than after D_1 (−16 ± 6 mmHg, $P < 0.01$) and D_2 (−10 ± 6 mmHg, $P < 0.05$). So were the values for DBP (−6 ± 2 mmHg, $P < 0.01$ and −5 ± 3 mmHg, $P < 0.01$, respectively). In addition, although PEP after D_3 was not significantly longer than after D_2, it was more prolonged than after D_1 (7 ± 5 ms, $P < 0.01$), demonstrating a continued increase in PEP under the effect of cumulative doses of diazepam. Thus, in Group 2, after 120 μg/kg of diazepam, SBP (−29 ± 18 mmHg,

TABLE 2. Mean Values ±SD of Hemodynamic Variables at Baseline (B) and after 30 (D_1), 60 (D_2) and 120 (D_3) μg/kg of Diazepam

	Group 1 (n = 9)				Group 2 (n = 9)			
	B	D_1	D_2	D_3	B	D_1	D_2	D_3
HR b/min	60 ± 10	60 ± 10	61 ± 10	62 ± 11	72 ± 22	70 ± 21	69 ± 19	65 ± 15
SBP mmHg	162 ± 36	163 ± 31	159 ± 33	152 ± 33	162 ± 15	149 ± 13*	143 ± 15*	133 ± 14*†
DBP mmHg	76 ± 10	77 ± 10	78 ± 11	75 ± 11	81 ± 8	77 ± 10‡	76 ± 11*	71 ± 11*§
PEP ms	90 ± 10	93 ± 14	91 ± 14	89 ± 10	93 ± 20	98 ± 23*	102 ± 25*	105 ± 23*
LVET ms	317 ± 27	314 ± 35	311 ± 34	310 ± 30	291 ± 44	285 ± 41	280 ± 37	280 ± 33
P/L·10^2	28 ± 5	30 ± 8	30 ± 8	28 ± 5	32 ± 9	34 ± 10	37 ± 11*	38 ± 11*
TEMS ms	409 ± 23	407 ± 24	403 ± 23	399 ± 25	384 ± 51	384 ± 44	382 ± 37	385 ± 31

Key: b/min = beats per minute. P/L = PEP/LVET ratio.
* Significant difference from baseline at $P < 0.01$ levels by Newmann-Keuls test.
† Significant difference between consecutive conditions at $P < 0.05$ levels by Newmann-Keuls test.
‡ Significant difference from baseline at $P < 0.05$ levels by Newmann-Keuls test.
§ Significant difference between consecutive conditions at $P < 0.01$ levels by Newmann-Keuls test.

$P < 0.01$) and DBP (-10 ± 6 mmHg, $P < 0.01$) decreased as compared with baseline while PEP (12 ± 6 ms, $P < 0.01$) and the ratio PEP/LVET·10^2 (6 ± 5.4, $P < 0.01$) increased as compared with baseline. Simple linear regression analysis between $LVEDP_{cath}$ and ΔPEP (response of PEP to 120 μg/kg of diazepam) yielded a correlation coefficient (r) of 0.77 ($P < 0.01$) for the least-squares equation, $\Delta PEP = -11.88 + 1.15\ LVEDP_{cath}$ (fig. 1). At baseline, Pa_{CO_2} values ranged from 31 to 39 mmHg in Group 1 and from 30 to 40 mmHg in Group 2. After D_3 they ranged from 30 to 41 mmHg in Group 1 and from 33 to 45 mmHg in Group 2. Overall, patients became very drowsy after D_2 and fell asleep after D_3, very often with complete disappearance of the eyelash reflex.

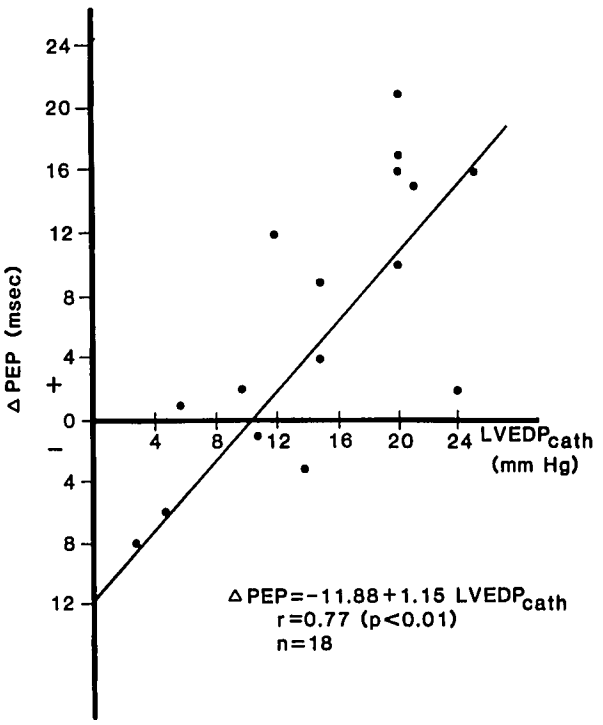

FIG. 1. Scattergram and regression line between ΔPEP (response of PEP to 120 μg/kg of diazepam as compared with baseline) and $LVEDP_{cath}$.

DISCUSSION

Our baseline hemodynamic data do not show any significant differences between the groups. Transient changes in LVEDP, large interpatient variability, and preoperative elevation of catecholamines,[6] compensating for LVEDP-dependent differences in STI, may have prevented STI baseline differences between the groups.

Diazepam induced cardiovascular changes in Group 2 patients whose SBP and DBP started to fall following 30 μg/kg. This could be attributed to a decrease in systemic vascular resistance[7] due to the effects of diazepam on smooth muscle,[8] autonomic ganglia,[7,9] catecholamine output,[10,11] and central pressor response[12] secondary to inhibition of the posterior hypothalamic centers.[13]

However, a hypotension of "pure" vasomotor origin should decrease ventricular afterload and improve ventricular performance. Under these conditions the fall in DBP and possible improvement in cardiac contractility should shorten the PEP and decrease the PEP/LVET ratio.[14] Instead, PEP lengthened and the PEP/LVET ratio increased, suggesting that the fall in blood pressure coincided with a decreased cardiac performance.

PEP does lengthen secondary to a failure in cardiac contractility or to a fall in LVEDP.[14] Diazepam decreases cardiac contractility in cats[12] and peak dp/dt in dogs.[15] In humans, Hemplemann *et al.*[16] observed that during neuroleptanesthesia, 0.3 mg/kg of diazepam reduced peak dp/dt by 26%. Considering the concomitant decreases in right and left atrial pressures, however, the Hemplemann team attributed the reduction in left ven-

tricular dp/dt to vasodilatation rather than to negative inotropic effect.

Diazepam has been reported to decrease venous tone.[17] The increase in venous capacitance can limit venous return and, as observed by Hemplemann *et al.*[16] and Côté *et al.*,[4] lower preload and LVEDP. Declining contractility or decreased preload can reduce stroke volume so that LVET shortens.[14] TEMS may remain unchanged, despite a prolongation of PEP. Without an increase in HR, cardiac output will fall. Hypotension will ensue if a compensatory vasoconstriction fails to increase systemic vascular resistance. Thus, the pattern of changes of STI observed here confirm the cardiac origin of diazepam-induced hypotension. The good linear correlation ($r = 0.77$, $P < 0.01$) between $LVEDP_{cath}$ and ΔPEP suggests that the diazepam-induced cardiac depression was more pronounced when $LVEDP_{cath}$ was more elevated. Whether a decrease in cardiac contractility or a fall in LVEDP was the cause of the decline in cardiac performance could not be determined on the basis of STI changes alone.

The commercial solvent used for diazepam contains 40% propyleneglycol. Clanachan *et al.* observed that, unlike diazepam, propyleneglycol had no significant effect on the isolated cardiac and smooth muscle of the rat.[8] However, benzyl alcohol, another solvent used in diazepam preparation, has been reported to have negative inotropic effects.[18] Thus the contribution of the solvent to the cardiovascular effects of diazepam remains controversial.

An elevated LVEDP is compatible with a failing ventricle in the presence of a lower ejection fraction (0.38 in Group 2 *vs.* 0.63 in Group 1 [$P < 0.001$] in this study) and severe abnormalities in left ventricular wall motion (table 1). Our observation that patients with elevated LVEDP react differently to pharmacologic challenges than those with normal LVEDP is not unique. Balasaraswathi *et al.* investigated the response to nitrous oxide (N_2O) in coronary patients with LVEDP both lower and higher than 15 mmHg at the moment of cardiac catheterization. They observed that patients with elevated LVEDP responded to N_2O with decreased cardiac output, stroke volume, and increased systemic vascular resistance, while the hemodynamic variables of patients with normal LVEDP did not change.[19] Patients with heart failure and elevated LVEDP respond differently to digoxin than patients with normal hearts.[20] When using M-mode echocardiography to assess preload by left ventricular end-diastolic dimensions (LVEDD), Packer *et al.*[21] observed that patients with LVEDD $\geq$ 60 mm responded differently to hydralazine from patients with LVEDD < 60 mm. Finally, Wilson *et al.*[22] reported that, in the presence of heart failure, the hemodynamic response to diuretics was determined by left ventricular geometry. Thus patients with elevated preload, whether determined by left ventricular end-diastolic pressure or dimensions, appear to belong to a population reacting differently to pharmacologic CV interventions.

On the one hand, the moderate systolic hypotension can be considered beneficial for the patient with coronary artery disease. SBP is one of the determinants of afterload. A lower SBP may reduce afterload and myocardial oxygen consumption, particularly if HR remains unchanged. On the other hand, the range of decrease of SBP was quite large (8–73 mmHg) and, although less, not negligible for DBP (0–23 mmHg). Using bolus injections and/or higher doses of diazepam may cause blood pressure to fall precipitously to dangerously low levels in some patients and jeopardize myocardial perfusion of right and left ventricles. It follows that diazepam should be titrated and used with caution in patients with coronary artery disease, particularly when LVEDP is elevated.

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