Patients with aortic stenosis: cardiac complications in non-cardiac surgery

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Purpose: To reassess the risk of patients with aortic stenosis (AS) undergoing non-cardiac surgery.

Methods: Following institutional approval, a retrospective chart audit of all patients with AS who underwent non-cardiac surgery in Hamilton between 1992 and 1994 was performed. For each AS case, a matching control was randomly selected. Data pertaining to pre-operative cardiac risk factors, intra-operative, and post-operative management were recorded. Complications were defined as the onset of congestive heart failure (CHF), myocardial infarction (MI), or dysrhythmias requiring cardioversion within seven post-operative days; unplanned or prolonged intensive care unit (ICU) stay due to cardiac cause; and cardiac death. Categorical data were compared using discordant data pairs and binomial distribution, with $\theta = 0.5$. Parametric data were compared using students' t test. All comparisons were two-tailed, with $\alpha < 0.05$ considered significant.

Results: 55 patients (32 male, 23 female, mean age 73 yr) with AS (mean aortic valve area 0.9 cm^2) were studied. Cases and controls were identical for eight of nine pre-operative risk factors. Differences in perioperative management were found. Cardiac complications occurred in five cases and six control patients ($P = 1.00$).

Conclusions: The current study, involving 55 patients with AS undergoing non-cardiac surgery, showed no difference in the risk of cardiac complications compared with matched controls. However, the intensification of management in the AS patients may have attenuated the risk in this group. The sample size was adequate to detect a fourfold increase in risk.

Objectif : Réévaluer le risque, chez les patients présentant une sténose aortique (SA), de subir une chirurgie non cardiaque.

Méthode : Après avoir obtenu l'accord de l'institution, nous avons procédé à un audit rétrospectif des fiches de tous les patients souffrant de SA qui ont subi une chirurgie non cardiaque à Hamilton entre 1992 et 1994. Pour chacun des patients SA, il y a eu l'appariement au hasard d'un cas témoin. Des données relatives aux facteurs de risque cardiaque préopératoire, à la prise en charge intraopératoire et postopératoire ont été enregistrées. On a reconnu comme complications la survenue d'une insuffisance cardiaque congestive (ICC), l'infarctus du myocarde (IM) ou les troubles du rythme nécessitant une cardioversion dans les sept premiers jours postopératoires ; un séjour non prévu ou prolongé à l'unité des soins intensifs (USI) en raison d'une cause cardiaque ; l'arrêt cardiaque. Des données catégorielles ont été comparées en utilisant des paires de données discordantes et une distribution binomiale, avec $\theta = 0.5$. Les données paramétriques ont été comparées selon le test t de Student. Toutes les comparaisons étaient bilatérales, avec $\alpha < 0,05$ considéré comme significatif.

Résultats : 55 patients (32 hommes, 23 femmes, dont l'âge moyen était de 73 ans) souffrant de SA (aire aortique moyenne de $0,9 \text{ cm}^2$) ont été étudiés. Les patients et les témoins présentaient des fiches identiques pour huit des neuf facteurs de risque préopératoire. Des différences de mesures périopératoires ont été trouvées. Les complications cardiaques sont survenues chez cinq patients et six cas du groupe témoin ($P = 1,00$).

Conclusion : La présente étude, réunissant 55 patients souffrant de SA et qui ont subi une chirurgie non cardiaque, n'a montré aucune différence de risque de complications cardiaques quand on les compare aux cas témoins qui leur sont appariés. Cependant, le renforcement des mesures thérapeutiques auprès des patients présentant une SA peut avoir atténué le risque dans ce groupe. Le nombre de sujets nécessaires à l'étude était suffisant pour détecter un accroissement de risque quatre fois plus grand.

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IN 1977, Goldman identified aortic valvular stenosis (AS) as an independent risk factor for the development of cardiac complications after non-cardiac surgery.¹ Despite the limited number of patients with AS in that study of 1001 patients (23 AS cases), patients with aortic stenosis are generally accepted to be at increased risk. Given the advances in anaesthetic management, the current study was undertaken to reassess the risk of cardiac complications after non-cardiac surgery for patients with AS.

Materials and methods

After approval from the health records department of each of the four acute care teaching institutions in Hamilton, a retrospective chart audit was performed. All medical records with a discharge diagnosis of AS and non-cardiac surgery between 1992 and 1994 were reviewed. All surgical cases requiring the care of an anaesthetist were included. Where multiple (separate) surgical procedures were performed on the same patient during the study period, one such procedure was randomly selected as the study case, using a random number table. Cases where AS was diagnosed subsequent to the development of post-operative complications were excluded.

A matching control was randomly selected for each AS case. Cases and controls were matched for sex, age ± 2 yr, operative procedure, as well as the calendar year and institution in which the procedure was performed.

According to the aortic valve area (AVA) measured by the most recent echocardiogram, cases were classified as mild ($1.00 - 1.6 \text{ cm}^2$), moderate ($0.8 - 0.99 \text{ cm}^2$) or severe ($<0.8 \text{ cm}^2$) AS.

Pre-operative data including age, sex, and the presence of risk factors for post-operative cardiac complications as defined by Goldman¹ and Mangano² were recorded.

Details of the intra-operative course, namely the surgical procedure, surgical time, the use of invasive pressure monitors (arterial, central venous, and pulmonary artery), and anaesthetic technique were recorded. Each anaesthetic technique was classified as follows: balanced general anaesthetic (GA), where GA was induced with an induction dose of thiopentone or propofol, and maintained with inhaled agent and opioid, with or without muscle relaxants; opioid GA, where GA was induced with $> 1 \mu\text{g}\cdot\text{kg}^{-1}$ sufentanil, or $> 10 \mu\text{g}\cdot\text{kg}^{-1}$ fentanyl, in conjunction with a subanaesthetic dose of hypnotic agent; central neuraxis anaesthetic, where a central block (epidural or spinal) was used with or without conscious sedation; combined technique, where GA (balanced or opioid) was used in combination with epidural opioid and/or local anaesthetic agent; conscious sedation, where subanaesthetic doses of hypnotic

ic or opioid agents were used with or without local infiltration or peripheral nerve block. Patients receiving a combined technique with opiate-based GA were classified under both techniques. The intensity of post-operative care, specifically the occurrence of an elective (planned) ICU admission, was recorded.

For all patients, the development of post-operative cardiac complications was recorded. Complications were defined as the onset of congestive heart failure (CHF) within seven post-operative days; myocardial infarction (MI) occurring within seven post-operative days; dysrhythmias requiring cardioversion within seven post-operative days; unplanned or prolonged intensive care stay resulting from cardiac complications; and cardiac death.

Categorical data between AS and control cases were compared using the discordant data pairs and binomial distribution, with $\theta = 0.5$. Parametric data were compared using students' *t* test; where continuous data failed the normality test, Wilcoxon signed rank test or Mann-Whitney rank sum test was used. Statistical comparisons were two-tailed and considered significant when $\alpha < 0.05$.

Results

During 1992 to 1994, 55 patients (32 male, 23 female) with uncorrected AS underwent non-cardiac surgery at one of four teaching institutions in Hamilton. Twelve patients underwent two or more procedures during the study period, of which one procedure per patient was randomly selected to be included in the study. Of the 55 AS cases, 24 had severe AS, 13 moderate AS, and 18 mild AS. Mean AVA was 0.9 cm^2 .

Cases and controls were identical in mean age (73 yr). The two groups were comparable in the incidences of all but one of the risk factors shown to predict post-operative cardiac complications. A history of CHF occurred more frequently in the AS case group ($P < 0.03$). (Table I)

The types of operative procedures performed are summarized in Table II. In each group, 43 elective and 12 emergency procedures were performed. The mean surgical time was equivalent between cases and controls (94.9 vs 97.5 min, *P*:NS). Regarding intra-operative management, the use of anaesthetic techniques and invasive monitors is summarized in Table III. The use of central venous pressure monitors ($P = 0.004$), and the use of opioid-based general anaesthesia ($P = 0.004$) was more common in the AS group. The use of balanced general anaesthesia was more common in the control group ($P = 0.0008$).

Regarding post-operative care, 13 cases compared with 9 controls had a planned post-operative ICU stay (*P*:NS).

TABLE I Risk factors for post-operative cardiac complications

<i>Risk Factor</i>	<i>Cases(55)</i>	<i>Controls (55)</i>	<i>P (for discordant pairs)</i>
History of angina	25	19	>0.2
MI within previous 6 mo	0	1	>0.5
MI prior to last 6 mo	12	16	>0.8
CHF in past	21	9	<0.03*
Raised jugular venous pressure	4	3	>0.9
Rhythm other than sinus rhythm	11	20	>0.1
> 6 ventricular ectopic beats per min	1	7	>0.09
receiving digoxin	11	9	>0.7
diabetes mellitus	9	5	>0.2

TABLE II Operative procedures

<i>Intra-abdominal (14)</i>	
hernia repair (2)	
anterior resection (3)	
laparoscopic cholecystectomy (2)	
open renal biopsy (1)	
staging pelvic lymphadenectomy (1)	
right hemicolectomy(1)	
exploratory laparotomy (1)	
retropubic urethropexy (1)	
radical cystectomy (1)	
abdominal hysterectomy (1)	
<i>Superficial Genitourinary (9)</i>	
urethrolithotomy (1)	
application of Tiersch wire (1)	
transurethral resection of prostate (3)	
cystoscopy, pyelogram (2)	
cystoscopy, resection bladder tumour (1)	
cone biopsy cervix (1)	
<i>Vascular (13)</i>	
abdominal aortic aneurysm repair (3)	
aortobifemoral bypass graft (1)	
femoral-popliteal bypass graft (1)	
carotid endarterectomy (2)	
popliteal embolectomy (1)	
repair brachial artery (1)	
insertion pacemaker (3)	
creation AV fistula (1)	
<i>Thoracic (1)</i>	
bronchoscopy, biopsy, pleuroscopy, talc poudrage (1)	
<i>Orthopaedic (14)</i>	
total knee arthroplasty (3)	
total hip arthroplasty (5)	
open reduction, internal fixation of hip fracture (3)	
arthroscopy wrist (1)	
forefoot amputation (1)	
open reduction, internal fixation of ankle fracture (1)	
<i>Ear, Eye, Nose, Throat, Dental (4)</i>	
extraction cataract, insertion lens (2)	
dental extractions (2)	

TABLE III Anaesthetic Management

<i>Intervention</i>	<i>Cases</i>	<i>Controls</i>	<i>P (for discordant pairs)</i>
Balanced GA	25	40	<0.001*
Opioid GA	10	1	0.004*
Combined technique	6	4	NS
Regional	10	7	NS
Conscious sedation	10	7	NS
arterial line	27	19	NS
central venous pressure monitoring	19	10	0.004*
pulmonary artery catheter	8	5	NS

Footnote: overlap between categories accounts for n>55 for anaesthetic techniques.

Cardiac complications occurred in five cases (one death) and six control patients (0 deaths, *P*:NS). (Table IV).

Given the 11% incidence in cardiac complications, the current study would have adequate power to detect a fourfold increase in risk in the AS group.

Discussion

The first study identifying aortic valvular disease as a risk factor for non-cardiac surgery was published in 1964.³ In this retrospective study, cardiac risk was evaluated in 766 patients (undergoing 857 non-cardiac procedures). A 10% mortality was found in the 59 patients with an "aortic lesion", although the group was not subdivided by type or severity of lesion. The high overall mortality (13%) in the study population likely reflects selection bias whereby only patients with pre-operative cardiac consultation were included. The absence of a control group makes it difficult to put the quoted mortality into perspective.

Goldman's multifactorial index of cardiac risk was published in 1977.¹ It was a prospective study evaluating 1,001 consecutive patients over the age of 40 yr, undergoing non-cardiac surgery. Patients with AS faced a 17.3% risk of cardiac complications and a 13% cardiac mortality rate, compared with a 1.6% cardiac mortality rate in patients without AS (an eightfold increase in cardiac death rate in patients with AS); however, only 23 patients with AS were included in the study.

Detsky⁴ confirmed Goldman's conclusion that patients with AS undergoing non-cardiac surgery are at high risk. However, in his study of 455 consecutive patients, only 13 were considered to have "important aortic stenosis". Thus, the conventional wisdom that patients with AS are at high risk for non-cardiac surgery is based on studies which are remote,^{1,3} of poor methodology,³ and which consist of very small series of patients.^{1,3,4}

TABLE IV Cardiac complications

Age, Sex	AVA	Procedure	Complication
65 yr, M	0.6 cm ²	bronchoscopy, biopsy, talc poudrage	CHF day 3, responding to diuretic therapy.
73 yr, M	1.1 cm ²	anterior resection	CHF day 1, requiring diuretics, ICU admission x 2 days.
84 yr, M	0.7 cm ²	abdominal aortic aneurysm repair	MI, CHF day 2, requiring diuretic therapy, mechanical ventilation. Prolonged ICU stay x 12 days. Death on day 12 due to ventricular dysrhythmias.
68 yr, M	1.1 cm ²	total hip arthroplasty	Ventricular fibrillation on day 0 (immediately post-op), requiring defibrillation. ICU admission x 4 days. No evidence for MI.
77 yr, F	0.9 cm ²	subtotal colectomy	MI, CHF day 1, requiring diuresis. ICU x 4 days.
72 yr, M	normal	anterior resection	CHF day 2, requiring diuresis, mechanical ventilation, ICU x 10 days.
69 yr, M	normal	ORIF hip fracture	CHF, MI day 6, ICU admission x 4 days, requiring diuresis and mechanical ventilation.
49 yr, F	normal	laparoscopic cholecystectomy	Intra-op ventricular tachycardia, asystole, requiring cardioversion. ICU 1 day. No evidence for MI.
x			
76 yr, F	normal	ORIF hip fracture	Unstable angina day 2. ICU x 2 days.
86 yr, F	normal	abdominal hysterectomy	MI, CHF, ventricular dysrhythmias day 1, requiring defibrillation, mechanical ventilation, diuresis, ICU admission x 7 days.
79 yr, M	normal	exploratory laparotomy	CHF day 0, responding to diuretic therapy, ICU admission x 1 day.

In 1988, O'Keefe *et al.* concluded that patients with AS could undergo non-cardiac procedures at reasonably low risk.⁵ In this retrospective review of 48 patients with AS, none sustained any severe cardiac complication after non-cardiac surgery. However, 25/48 procedures were relatively minor, being performed under local anaesthesia. Furthermore, the absence of matched controls prevents evaluation of the baseline risk for patients without AS undergoing similar procedures in their institution.

The current study failed to show an increase in the risk of cardiac complications after non-cardiac surgery in patients with AS compared with matched controls. There are five possible explanations for this finding.

Firstly, and most importantly, the small sample size may account for an inability to detect an increased risk in AS patients, where, in fact, such an increase risk does exist (β error). The current study has adequate power to detect a fourfold increase in risk. In order to detect a twofold increase in risk, 180 cases (with 180 matched controls) would be required. This would necessitate a ten year review period, or a multicentre review.

Secondly, it is possible that such an increase risk, as previously reported, no longer exists. The present study, as the most recent, more accurately reflects modern anaesthetic and surgical techniques. However, despite being the largest series to date, the current study has very limited power.

Thirdly, it is possible that patients with AS face an inherently higher risk when undergoing non-cardiac surgery, but that the risk is attenuated by deliberate enhancement of anaesthetic management in these patients. A previous study has suggested that intensification of perioperative management may decrease the incidence of post-operative cardiac morbidity and

mortality in high-risk patients.⁶ In the current study, we showed an increase in the use of central venous pressure monitoring and opioid-based anaesthesia in AS cases than in controls. The use of arterial pressure monitoring approached but did not reach significance with two-tailed testing. Two-tailed tests were used as it was not known in advance whether cases or controls would present with more risk factors, and therefore warrant a more cautious anaesthetic approach.

Fourthly, it is possible that the limitations of the retrospective study precluded the detection of elevated risk in AS patients. Bias may be present, both in selection of cases and controls, as well as in the estimation of outcomes.

The selection of cases was based on the discharge diagnosis of AS. Some patients with AS may have failed to have their diagnosis properly recorded, through either lack of awareness or attention on the part of the most responsible physician. Such an error would tend to occur in patients with mild or moderate AS, thus causing the severe AS group to be over-represented, and increasing the likelihood of detecting a difference from controls.

Selection bias may also occur in the pre-operative phase by the surgeon or anaesthetist. Results from our study suggest that patients with severe AS presented less frequently for complicated, prolonged procedures than did patients with mild or moderate AS. The median surgical time in the severe AS group was less (60 min for 24 severe AS cases), than in the non-severe AS group (100 min for 31 non-severe AS cases), $P < 0.02$.

Controls were selected randomly from a list of suitable matches. If by random effect, the selected controls were not representative of the control population, and thereby "higher risk", then this would blunt, or even

preclude the detection of an elevation in risk in the AS cases. However, our analysis shows that the controls were equivalent to cases for all risk factors, except for "history of CHF", which was present more frequently in AS patients.

Both an over- and underestimation of outcomes can occur in a retrospective study. Case-control studies have been known to find more outcomes in the cases, which would exaggerate the risk, rather than to cause one not to be found. Because outcomes are determined by chart review, rather than by systematic laboratory tests (cardiac enzymes, chest x-ray, electrocardiogram), subclinical outcomes (such as silent MI or mild interstitial pulmonary edema) may have been overlooked. Such a bias, however, would exist for both cases and controls.

Fifthly, the advanced mean age in both cases and controls (73 yr) may have obscured the effect of AS on the overall cardiac risk.

Conclusions

Patients with AS have been considered to be at high risk for non-cardiac surgery. Such a conclusion is based on studies of small series of patients, which predate current surgical and anaesthetic care.

The current study involving 55 patients with AS was unable to detect a difference in the risk of cardiac complications after non-cardiac surgery compared with 55 matched controls. However, the sample size was adequate to detect no less than a fourfold increase in risk in patients with AS undergoing non-cardiac surgery. In order to resolve the question as to whether patients with AS are at increased risk for non-cardiac surgery, a larger review would need to be undertaken. We demonstrated an intensification of anaesthetic management in the AS cases, which may or may not have accounted for the absence of increased risk in the AS cases.

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