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Anaesthetic Considerations for Patients with Severe Aortic Stenosis

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1. Introduction

Valvular heart disease has significant effect on the outcome of practically any kind of surgical procedure involving general or regional anaesthesia. The most frequently encountered cardiac valve lesions produce pressure overload (mitral stenosis, aortic stenosis) or volume load (mitral regurgitation, aortic regurgitation) on the left atrium or left ventricle. Anaesthetic management during the perioperative period is based on the likely effects of drug induced changes in cardiac rhythm, heart rate, preload, afterload, myocardial contractility, systemic blood pressure, systemic vascular resistance and pulmonary vascular resistance relative to the pathophysiology of the heart disease.[1]

1.1 Clinical essentials of aortic valve disease

Timely diagnosis and treatment of diseases of the aortic valve is essential to avoid fatalities such as intra or post-operative heart failure, severe infection, in extreme cases sepsis, or even sudden death. Some patients present with severe symptoms, whereas others have few or hardly any symptoms at all. The diagnosis may be made on a routine physical examination performed at the ward or a pre-operative assessment. Regular medical follow-up, treatment to prevent infection of the valve (infective endocarditis), and optimal timing of surgery are necessary to avoid the severe consequences of improper functioning of the aortic valve. [2]

As described earlier the ability of the left ventricle to generate the stroke volume (SV) depends on adequate filling or “preload,” the contractile state of the muscle, and the impedance to ejection (“afterload”). Valvular lesions impose additional requirements for compensation. Thus, stenotic lesions require the heart to force an adequate volume through a small orifice; regurgitant lesions on the other hand require the heart to eject a large volume because part of the ejected volume returns backwards. Compensation involves both the myocardium and the peripheral vasculature. Preoperative assessment in all patients with valve disease should include a recent (i.e. at least within 6 months) evaluation such as echocardiography, and a detailed assessment of symptom progression [3].

It is very important to Assess, Plan and Administer.

Asses the degree of the valvular lesion preoperatively

Plan with a multidisciplinary team based on the assessment

Administer the proposed drug therapy particularly antibiotics.

The severity and extent of aortic stenosis is of great value for risk assessment and for the design of a therapeutic plan. The plan which involves a detailed preoperative assessment and preparation, intra-operative caution and strict monitoring and post operative care can be further complicated with the association of other anomalies like genetic disorders, auto immune disorders or severe obesity.

2. How valvular disease affects anaesthetic procedures

Aortic stenosis is the commonest of the major valve lesions. While rheumatic disease was historically the most important cause, this has been displaced by degeneration of congenital bicuspid disease. This latter abnormality occurs in 1-2% of the population. Elderly patients may also have significant "senile" degeneration of a normal (tricuspid) aortic valve. Both rheumatic disease and congenital bicuspid disease become hemodynamically significant over a period of decades, with patients presenting with symptoms and the need for valve replacement usually during or after the 5th decade.[3] The gradual process of narrowing of the aortic orifice leads to concentric left ventricular hypertrophy and a reduction in left ventricular compliance – the myocardium becomes thick, the end-diastolic pressure rises, but there is no dilatation. Typically this occurs as the valve area decreases over years from the normal 2.5 – 3.5 cm^2 to about 1 cm^2. The left ventricle generates very high systolic pressures to overcome the stenosis, but aortic pressures are normal. Because of the decreased compliance, LV filling during diastole depends on adequate preload as well as atrial contraction. While the latter contributes less than 20% of filling in the normal heart, it may contribute twice this amount in AS. This phase of AS is termed "mild" stenosis with physiologic compensation. As the aortic valve area diminishes below 1 cm^2 down to 0.5 cm^2, the stenosis is termed "moderate." Patients begin to develop symptoms as the heart struggles to maintain flow through the narrowing lesion. The increased work of the heart in association with decreased compliance and increased LVEDP results in angina in the majority of patients. This occurs in the absence of coronary artery disease (CAD), although up to 50% of patients may have significant CAD.[4] The left ventricle begins to dilate, the atrium may develop fibrillation, and the patient begins to experience symptoms of pulmonary congestion or even syncope with any type of excitement or exertion. "Critical" stenosis is present if the valve area is less than 0.5 cm^2. The onset of angina is associated with an average survival of 5 years; heart failure or syncope are associated with less than 3 years survival.[5] Valve replacement is recommended when the valve area is less than 0.8 cm^2 or if there is ventricular dysfunction, ventricular ectopy or an inadequate blood pressure response to exercise. Percutaneous balloon valvuloplasty is possible in selected patients.

2.1 The detailed assessment

2.1.1 Preoperative assessment

The main aim of such an assessment is to determine the risks of the patient suffering from peri and/or postoperative deterioration of health and plan its prevention. Severe valvular disease in patients presenting for noncardiac surgery is a major predictor of increased peri-operative cardiovascular risk, mandating intensive management that may result in delay or cancellation of, or pre-operative intervention before, surgery except in the case of emergency surgery[4]. Symptomatic stenotic lesions (aortic and mitral valve stenosis) are associated with a higher risk of peri-operative cardiac complications than symptomatic regurgitation (aortic or mitral valve insufficiency), which is usually better tolerated in the peri-operative setting or may even be stabilized pre-operatively with medical pretreatment[4]. The valvular disease with the highest risk for the non-cardiac surgical patient is severe aortic stenosis.

2.1.1.1 Meeting the patient

A review of the patient's history and medical records to be sure the degree of stenosis, both clinically and objectively is appreciated. This review may result in a referral for valve replacement or valvuloplasty. Questions designed to define exercise tolerance are necessary to evaluate cardiac reserve to provide a functional classification according to the criteria established by the New York Heart Association (NYHA). When myocardial contractility is impaired patients complain of dyspnoea, orthopnea, and easy fatigability, a compensatory increase in the sympathetic nervous system activity may manifest as anxiety, diaphoresis, and resting tachycardia. Congestive heart failure (CHF) is a frequent complication of chronic valvular heart disease and its presence is noted by basilar chest rales, jugular venous distension and a third heart sound on physical examination. Cardiac dysrhythmias are common with valvular heart disease; angina pectoris may occur in patients with valvular heart disease even in the absence of coronary disease due to increased myocardial oxygen consumption and demand for the hypertrophied myocardium. Valvular heart disease and ischemic heart disease (IHD) frequently co-exist. 50% of patients with aortic stenosis who are older than 50 year of age have associated IHD. The presence of CAD with mitral or aortic valve disease worsens the long term prognosis.

Class	Description
I	Asymptomatic
II	Symptoms with ordinary activity but comfortably at rest
III	Symptoms with minimal activity but comfortable at rest
IV	symptoms at rest

Table 1. NYHA functional classification of patients with heart disease [1]

2.1.1.2 Charting out the assessment form

Filling out the assessment form is the very backbone of the procedure to follow. Apart from the neurological, cardiac, respiratory, nephrology, gastrointestinal history, it is very important to discuss the use of the patient's own medication prior to the surgical procedure. Allergies and complications during previous procedures should not be neglected. Detailed information should be availed regarding the discontinuation of anticoagulants like clopidogrel and its substitution by low molecular weight heparin 10 days before and immediately after the procedure.

2.1.1.3 Discussing anaesthesia with the patient

The patient should be informed about the procedure preferably in the presence of the surgeon. This way any question regarding the surgical details of the procedure can be answered appropriately. The patient has to be informed clearly regarding the steps of the anaesthetic procedure starting from leaving the ward through the events in the operating theatre until reaching the intensive care unit. He/she needs to be reassured about optimal analgesia during the procedures involved. Proper information regarding the risks of the anaesthetic procedure and their possible solutions should be clarified.

2.1.1.4 Discussing the procedure with the relative, *parent in case of child*

In many cases patients prefer the preoperative assessment in the presence of their spouse or a relative. In case of children informed consent from the parent is essential. Any major surgical procedure and particularly cardiac surgery may spark fear of death during the procedure amongst patients and their relatives. Questions like 'Will I wake up after the procedure?' should be answered correctly, reassuring the patient and their relatives about the safety of the anaesthetic equipment, skill and care. Informed consent is essential prior to emergency procedures as well.

2.1.1.5 Discussing the anaesthetic plan with the surgical/interdisciplinary team

Details regarding the anaesthetic procedure and postoperative care need to be discussed well with the surgical side for each patient in order for allowing swift coordination and reduction of the possibility of error. In many cases not just the surgeon and the anaesthesiologist is involved but suggestions, investigations, examinations and consultation is required form cardiologists, obstetricians, psychiatrists, neurologists or other specialists. It is therefore essential to form a multidisciplinary team to ensure safe practice. The use of multidisciplinary protocols and drills are advised for emergency procedures.

2.1.1.6 Preparing the patient for surgery

The preparations start from the point the patient has been assessed pre-operatively but prior to the procedure it is essential that the anaesthetist personally visits the patient and preferably accompanies her or him to the operation theatre. Anxiety can cause serious problems before surgery. Anxiolysis might decrease the patient's anxiety and hence decrease the sympathetic output which increases the heart rate, an undesirable parameter in patients with aortic stenosis, digitalis, ß blockers can be used for heart rate control which is essential for ventricular filling. Therefore pre-medication and anxiolytics hold an important place in preparing the patient for surgery. Introduction to the staff in theatre and friendly behaviour creates a stress free environment are useful to avoid unnecessary cardiovascular complications.

Pre-operative management depends on the urgency of surgery and includes the following options:

- open surgical repair before the non-cardiac surgical procedure;
- balloon valvuloplasty before the non-cardiac surgical procedure;
- clearance for surgery without further pre-operative intervention;
- cancellation.

In recently published guidelines[6], it is recommended that, if the aortic stenosis is severe and symptomatic, elective non-cardiac surgery should be postponed and aortic valve replacement performed before elective surgery. If the patient is not a candidate for valve replacement or surgery is semi-elective, balloon valvuloplasty may be performed.

In patients without left ventricular failure, the mortality following aortic valve replacement ranges from 2% to 9% in most centres and may be as low as 1% in patients under the age of 70 years. Concomitant coronary artery disease and poor left ventricular (LV) function are the most important variables affecting overall survival rate [7, 8].

If the patients are not candidates for aortic valve replacement or balloon valvuloplasty, non-cardiac surgery may be performed without pre-operative intervention in a selected group of patients at an acceptably low risk, probably because peri-operative anaesthesiological and surgical management has improved substantially over the past decade[9, 10]. In two recent studies, peri-operative mortality ranged from 1.9% to 7.1%. Peri-operative morbidity included pulmonary oedema in 17.3% of cases, which was effectively treated, and myocardial infarction in 1.9%[9, 10].

2.1.1.6.1 Premedication

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2.1.1.6.2 Endocarditis prophylaxis

Prophylaxis against infective endocarditis is reasonable for the following patients at highest risk for adverse outcomes from infective endocarditis who undergo dental procedures that involve manipulation of either gingival tissue or the periapical region of teeth or perforation of the oral mucosa[11]:

- Patients with prosthetic cardiac valve or prosthetic material used for cardiac valve repair.
- Patients with previous infective endocarditis.
- Patients with CHD.
- Unrepaired cyanotic CHD, including palliative shunts and conduits.
- Completely repaired congenital heart defect repaired with prosthetic material or device, whether placed by surgery or by catheter intervention, during the first 6 months after the procedure.
- Repaired CHD with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device (both of which inhibit endothelialization).
- Cardiac transplant recipients with valve regurgitation due to a structurally abnormal valve.

Prophylaxis against infective endocarditis is not recommended for nondental procedures (such as transoesophageal echocardiogram, esophagogastroduodenoscopy, or colonoscopy) in the absence of active infection. *[11]*

2.2 Monitoring during anaesthesia
2.2.1 Non-invasive monitoring
2.2.1.1 ECG

Although even a single post-operative ECG demonstrating ischemia in the recovery room is predictive of a major cardiac complication later during the hospital stay, ECG monitoring alone is not adequate to detect ischemia in real time in the intensive care unit (ICU) and intraoperative settings [12-14]. Specifically, conventional visual ECG monitoring for the detection of transient ST segment changes is inaccurate[14]. Although lead V5 has been known as the best choice for the detection of intraoperative ischemia for many years [15, 16] one study found that lead V4 was more sensitive and appropriate than lead V5 for detecting prolonged post-operative ischemia and infarction [17]. Leads are not specific for ischemic events, and, furthermore, ischemic events are dynamic and may not always appear in the same lead. If a single lead is used for monitoring, there is an increased risk of missing ischemic events. With the use of selected lead combinations, more ischemic events can be precisely diagnosed in the intraoperative setting. In one study, although the best sensitivity was obtained with lead V5 (75%), followed by lead V4 (61%), combining leads V4 and V5 increased the sensitivity to 90%.198 In the same study, when three leads (II, V4, and V5) were used simultaneously, the sensitivity increased to 96%.198 Similarly, in another study in which two or more precordial leads were used, the sensitivity of ECG monitoring was >95% for detection of perioperative ischemia and infarction [17]. It was also shown that ECG monitoring with fewer leads (as few as three leads) had lower sensitivity than monitoring with 12 leads, and there was a statistically significant association, independent of perioperative troponin values, between perioperative ischemia on a 12-lead ECG and long-term mortality [18-20]. Thus, 12-lead ECG monitoring is recommended especially with high-risk patients.

	Agent	Adult**	Children**
Oral	Amoxicillin	2 g	50 mg/kg
Unable to take oral medication	Ampicillin Cefazolin or ceftriaxone	2 g IM or IV 1 g IM or IV	50 mg/kg IM or IV 50 mg/kg IM or IV
Allergic to penicillins or ampicillin—oral	Cephalexin†‡ Clindamycin Azithromycin or clarithromycin	2 g 600 mg 500 mg	50 mg/kg 20 mg/kg 15 mg/kg
Allergic to penicillins or ampicillin and unable to take oral medication	Cefazolin or ceftriaxone‡ Clindamycin	1 g IM or IV 600 mg IM or IV	50 mg/kg IM or IV 20 mg/kg IM or IV

†Or use other first- or second-generation oral cephalosporin in equivalent adult or pediatric dosage.
‡Cephalosporins should not be used in an individual with a history of anaphylaxis, angioedema, or urticaria with penicillins or ampicillin.
IM indicates intramuscular; and IV, intravenous.
** Regimen single dose 30-60 min before the procedures.

Table 2. Regimens for dental procedures

Recommendation	Class[a]	Level[b]
12-lead ECG monitoring is recommended for all patients undergoing surgery	I	C
Selected lead combinations for better ischemia detection in operation room should be considered	II_a	B

ECG, electrocardiograph. [a] Class of recommendation. [b] Level of evidence.

Table 3. Recommendations on 12-lead ECG monitoring

2.2.1.1.1 Other routine non-invasive monitoring

Standard non-invasive procedures also apply including pulse oximetry, end tidal carbon dioxide monitoring with capnograph, and temperature measurement.

2.2.2 Invasive haemodynamic monitoring

2.2.2.1 Transoesophageal echocardiography

TOE is recommended if acute and severe haemodynamic instability or life-threatening abnormalities develop during or after surgery[21].The main advantage of TOE over pulmonary artery catheterization is the more comprehensive evaluation of cardiac structure and function. Information is quickly available on regional or global, right and/or LV dysfunction, the presence of tamponade or cardiac thrombi, and preload estimation through the measurement of end-diastolic volume. Numerous indices of ventricular and atrial function have been proposed. However, most parameters are load dependent. The role of TOE for haemodynamic monitoring in patients at risk is more controversial. Automated analysis systems exist but are not yet sufficiently validated. There is no evidence that haemodynamic monitoring by TOE accurately stratifies risk or predicts outcome. TOE can be useful in the operating room in patients with severe valvular lesions. The loading conditions during general anaesthesia differ from those present in the preoperative evaluation. Functional and ischemic mitral regurgitation are usually reduced during general anaesthesia. Organic mitral regurgitation can, conversely, increase. In the setting of severe mitral regurgitation, the LV ejection fraction overestimates LV function, and other parameters may be more accurate, such as myocardial velocities or deformation obtained by tissue Doppler imaging or 2D speckle tracking, an angle independent method. These are promising techniques, but more validation is needed before they can be used routinely in this setting. In patients with severe aortic stenosis, appropriate preload is important during surgery. Monitoring of LV end-diastolic volume may be more accurate than that of pulmonary capillary pressure. An appropriate heart rate is crucial in patients with mitral stenosis and aortic regurgitation: a long diastolic period in the former and shorter duration of diastole in the latter. When inappropriate control of heart rate occurs, the consequences should be assessed: changes in transmitral mean gradient and pulmonary arterial pressures in mitral stenosis and changes in LV volumes and indices of LV function in aortic regurgitation.

Recommendations on intraoperative and/or perioperative TOE in patients with or at risk of haemodynamic instability	**Class[a]**	**Level[b]**
TOE is recommended when acute sustained severe haemodynamic disturbances develop during surgery or in the perioperative period	I	C
TOE monitoring may be considered in patients at increased risk of significant haemodynamic disturbances during and after major non-cardiac surgery	II$_b$	C
TOE monitoring may be considered in patients who present severe valvular lesions during major non-cardiac surgical procedures accompanied by significant haemodynamic stresses	II$_b$	C

TOE, transoesophageal echocardiography. [a] Class of recommendation. [b] Level of evidence.

2.2.2.2 Invasive arterial blood pressure monitoring

Invasive arterial blood pressure (IABP) measurement by means of an intra-arterial cannula is a key monitoring technique in high-risk patients both intra-operatively and on the intensive care or high-dependency unit. In addition to giving beat-to-beat blood pressure, the IABP system is increasingly being utilized as the basis of a variety of real-time haemodynamic monitoring systems based on pulse pressure1 or contour.[22]

Its use in Aortic stenosis setting will allow real time beat to beat visualization and hence being proactive rather than reactive to any changes in blood pressure a parameter whose narrow fluctuations might decompromise the haemodynamics in tight valve lesions.

2.2.2.3 The pulmonary artery catheter

Aortic stenosis subjects the left ventricle to excessive afterload, resulting in hypertrophy and a loss of compliance. Unlike the afterload imposed by hypertension, the systemic circulation and especially the coronary circulation are subjected to reduced rather than elevated pressures. Coronary blood flow is impaired by systemic afterload reduction, increased ventricular diastolic pressure and tachycardia which reduces diastolic perfusion time, all may result in angina. Preload must be maintained for the left ventricle to generate an adequate cardiac output across the stenotic valve. Given a noncompliant ventricle, small changes in fluid loading result in large changes in filling pressures.

Critical aortic stenosis creates a narrow window of appropriate fluid loading. Small decrease in preload due to haemorrhage or regional anaesthesia may result in decreased cardiac output and clinical hypotension. Small increases in vascular volume may cause dramatic increases in filling pressures, resulting in pulmonary oedema.

The goal of haemodynamic management should be to maintain filling pressures within the narrow therapeutic window and to avoid tachycardia***.[23]***

2.2.2.4 Glucose monitoring

Diabetes mellitus is an important risk factor for perioperative cardiac complications and death. This condition promotes atherosclerosis, endothelial dysfunction, and activation of platelets and proinflammatory cytokines. Surgical stress is associated with haemodynamic stress and vasospasm and further enhances the prothrombotic state, while inhibiting fibrinolysis. Hyperglycaemia in the absence of established diabetes plays an important role, emphasizing the need for pre-operative management of hyperglycaemia where possible.

Importantly, impaired glucose tolerance is often identified only after glucose loading. Data from the International Diabetes Foundation reveal a high and increasing prevalence of diabetes in Europe, rising from 7.8% in 2003 to 8.4% in 2007, with an estimated prevalence of at least 9.1% by 2025. [24]

More than 30% of the cases were previously undiagnosed, pointing to underestimation of the problem. With ~48 million people affected, diabetes has become one of the main causes of morbidity and mortality in Europe. According to the World Health Organization, ~50% of these patients die of CVDs cardiovascular diseases. It has been well established that surgery in patients with diabetes is associated with longer hospital stay, higher healthcare resource utilization, and greater perioperative mortality. More recently, the emphasis has shifted from diabetes to hyperglycaemia on its own. New-onset hyperglycaemia, as compared with hyperglycaemia in known diabetics, may hold a much higher risk of adverse outcome[25]**.**

Evidence for strict blood glucose control for patients without known diabetes undergoing non-cardiac surgery is largely derived from studies in critically ill patients.[26] the Leuven

prospective randomized controlled study demonstrated major clinical benefits for surgical ICU patients whose blood glucose levels were maintained normal (5.0–5.6mmol/L; 90–100 mg/dL) with intensive insulin therapy, compared with patients who received conventional glucose management and developed hyperglycaemia (8.3–8.9 mmol/L; 150– 160 mg/dL)[27]. These benefits included lower ICU and in-hospital mortality and prevention of several critical illness-associated complications (critical illness polyneuropathy, severe infections, acute renal failure, and prolonged dependency on mechanical ventilation and intensive care). Also, long-term outcome improved, as shown for the cardiac surgery subgroup. Five years later the Leuven group reported findings from the medical ICU, showing prevention of morbidity, but no mortality benefit from intensive glucose control, except in a subgroup requiring critical care for 3 days [28].
Several risk factors for cardiac events after non-cardiac surgery are attenuated with strict blood glucose control in the ICU, including endothelial injury/dysfunction, CRP, and asymmetric dimethylarginine, apart from effects on mitochondrial damage, serum lipid profile, and the cortisol response. No effects, or only marginal ones, were seen on cytokines, coagulation, and fibrinolysis.

Recommendations	**Class[a]**	**Level[b]**
Postoperative prevention of hyperglycaemia (targeting levels at least below 10 mmol/L with intensive insulin therapy is recommended in adults after high risk or complicated major surgery requiring admission to ICU	I	B
Intraoperative prevention of hyperglycaemia with insulin may be considered	II_b	C
Postoperative prevention of hyperglycaemia with insulin after uncomplicated elective surgery may be considered	II_b	C

ICU, Intensive care unit. [a] Class of recommendation. [b] Level of evidence

Table 4. Recommendations on blood glucose control

3. Anaesthetic considerations

The objectives of anaesthesia in patients with aortic stenosis include the prevention of hypotension and any haemodynamic change that will increase the cardiac output.
Normal sinus rhythm must be maintained because the left ventricle is dependant on a properly timed atrial contraction to produce an optimal left ventricular end-diastolic volume. Loss of atrial contraction loosing the atrial kick, as during junctional rhythm or atrial fibrillation may produce a dramatic decrease in stroke volume and blood pressure. The heart rate is important because it determines the time available for ventricular filling, for ejection of the stroke volume, and for coronary perfusion. A sustained increase in heart rate decreases the time for left ventricular filling and ejection and reduces cardiac output. Hypotension reduces coronary blood flow and results in myocardial ischemia and further deterioration in left ventricular function and cardiac output. Aggressive treatment of hypotension is mandatory to prevent cardiogenic shock and/or cardiac arrest. Cardiopulmonary resuscitation is unlikely to be effective in patients with aortic stenosis because it is difficult, if not impossible, to create an adequate stroke volume across a stenotic aortic valve with cardiac compression[1].

3.1 General anaesthesia

General anaesthesia is often selected in preference to epidural or spinal anaesthesia because the sympathetic blockade produced by regional anaesthesia can lead to significant hypotension. [1]Nevertheless controversies do exist as for the careful titration of regional anaesthetic technique that might provide a favourable heamodynamic profile (see below).

Induction of anaesthesia can be with an intravenous induction drug that does not decrease the systemic vascular resistance. An opioid may be useful if left ventricular function is compromised.

Maintenance of anaesthesia with a combination of nitrous oxide and volatile anaesthetic and opioid or by opioid alone. Advisable to avoid drugs depressing the sinus node to preserve atrial contraction which has an important role in the ventricular filling. Drugs that depress sinus node automaticity can produce junctional rhythm and loss of the properly timed atrial contraction. If left ventricular function is impaired, it is prudent to avoid any drugs that can cause additional depression of myocardial contractility. A decrease in systemic vascular resistance is very devastating. Maintenance of anaesthesia with nitrous oxide plus opioid or with opioids alone in high doses is recommended for patients with marked left ventricular dysfunction. Neuromuscular blocking drugs with minimal haemodynamic effects are best used. Intravascular volume should be maintained at normal levels. The onset of junctional rhythm or bradycardia during anaesthesia and surgery requires treatment with glycopyrolate, atropine, or ephedrine. Persistant tachycardia can be treated with ß blockers such as esmolol. Supraventricular tachycardia should be promptly terminated with electrical cardioversion. Lidocaine and defibrillator should be kept available as these patients have a propensity to develop ventricular dysrhythmias[1].

3.2 Epidural block

There is a lack of evidence based guidelines as for the best choice of regional technique to be used in patients with aortic stenosis to provide anaesthesia and analgesia. Patients with hip fractures for instance and cardiac co-morbidities benefit more from epidural analgesia than from opioid analgesia technique in terms of pain and reduced postoperative cardiac events [29]. In major knee surgery it has been demonstrated that earlier rehabilitation can be achieved by using epidural blockade in contrast to i.v. patient controlled morphine [30].

So what is the rule?, When anaesthetizing a patient with aortic stenosis, the haemodynamic goals include avoiding sudden and profound decreases in systemic vascular resistance, maintaining contractility and sinus rhythm and avoiding hypovolaemia and tachycardia (as mentioned earlier in the general anaesthesia section). Epidural blockade facilitate a gradual onset of anaesthesia and sympathetic block, and therefore a sudden and profound decrease in systemic vascular resistance is avoided. With incremental doses of local anaesthetics, an even higher degree of control is attained. Epidural anaesthesia does not affect myocardial contractility and with proper fluid loading, good control of the circulation can be accomplished.

There are some studies e.g. Ho et al. suggested the use of hypotensive epidural anaesthesia in patients with aortic stenosis undergoing total hip replacement and rendered satisfactory results provided that the stenosis is asymptomatic and non-critical. Nevertheless the choice of anaesthesia in such cases should be made on individual basis and in the presence of skilled anaesthetist [31].

3.3 Spinal anaesthesia

Although general anaesthesia is historically considered the anaesthetic of choice for patients with aortic stenosis, Continuous spinal anaesthesia is an attractive alternative for the management of surgery on the lower extremities when used with appropriate invasive monitoring.

Central neuroaxial blockade has been contraindicated in patients with severe aortic stenosis [32-35], because sympathetic blockade produced can rapidly cause a marked decrease in systemic vascular resistance with decreased venous return to the heart and coronary perfusion pressure. Large decreases in systemic vascular resistance, therefore, should be avoided to prevent the catastrophic cycle of hypotension-induced ischemia, subsequent ventricular dysfunction, and worsening hypotension. Indeed, hypotension-induced ischemia with resultant ventricular dysfunction has been described in patients with left ventricular outflow tract obstruction receiving spinal anaesthesia[36]. Recently, several authors have reported greater hemodynamic control achieved with continuous spinal anaesthesia over epidural or single-dose spinal anaesthesia in healthy patients [37, 38].

When regional anaesthesia is selected, epidural rather than spinal anaesthesia is often recommended, but continuous spinal anaesthesia offers many of the advantages of epidural anaesthesia. With the appropriate invasive monitoring, the onset of peripheral sympathetic block develops in a gradual and controlled fashion using continuous spinal anaesthesia. An additional advantage over epidural anaesthesia in that catheter placement is technically easier and aspiration of CSF provides confirmation of correct catheter placement, also the catheter can be left in place like an epidural catheter offering postoperative pain management, minimizing the need for systemic opiates and their attendant risks. However, the potential higher incidence of respiratory depression with spinal versus epidural opiate administration should not be overlooked [39].

Continuous spinal anaesthesia avoids many of the disadvantages of general anaesthesia. In contrast to general anaesthesia, use of a continuous spinal catheter allows patient communication of subjective feelings of distress throughout the operation. In addition, the hemodynamic perturbations of direct laryngoscopy and intubation are avoided with continuous spinal anaesthesia. Moreover, the use of volatile anaesthetics in patients with aortic stenosis may lead to myocardial depression, peripheral vasodilation, and loss of normal atrial systole. Likewise, continuous spinal anaesthesia obviates the need for neuromuscular blockade, which may lead to undesirable fluctuations though newer agents have fewer effects on heart rate.

However, continuous spinal anaesthesia has potential complications:

It should be used with caution in patients in whom a difficult endotracheal intubation is anticipated. Peripheral sympathetic nervous system block produced by continuous spinal anaesthesia may be deleterious in situations of profound blood loss. This is especially true in the setting of aortic stenosis where precipitous decreases in systemic vascular resistance can lead to the catastrophic cycle of hypotension-induced ischemia, subsequent ventricular dysfunction, and worsening hypotension. Aortic stenosis is often complicated by global ventricular hypokinesis and atrial fibrillation. These patients are often anticoagulated and Continuous spinal anaesthesia would be contraindicated. Finally, many of the complications associated with single-dose spinal anaesthesia including postdural puncture headache, persistent paresthesia, low back pain, and risk of infection also apply to continuous spinal anaesthesia.

3.3.1 Pulmonary artery catheter management under continuous spinal anaesthesia

a. Low CVP and PCWP: warrants the administration of e.g. crystalloids or colloids to regain PCWP to the preoperative value, if this measure fails , it is advisable to add a vasoconstrictor to increase the systemic vascular resistance and cardiac filling pressures.
b. In case of crystalloids usage and sudden increase in the PCWP of 3-4 mmHg upon administering 15ml/kg , so the infusion should be stopped immediately.
c. Pulmonary artery catheter carries the advantage of detecting pulmonary hypertension, and left ventricular failure as a result of decreased left ventricular filling and decrease compliance[40]
d. Inotropes should be considered in those with hypotension and high PCWP.

Ephedrine should be used cautiously in the patient with aortic stenosis, as the resultant tachycardia may precipitate myocardial ischemia. With the aide of invasive hemodynamic monitoring, there is a successful induction and maintenance of Continuous spinal anaesthesia in a controlled fashion while maintaining control of the cardiac filling pressures.

3.4 Post-operative pain management

Post-operative pain is a major concern, reported in 5–10% of the patients. It may increase sympathetic drive and delay recovery [41, 42]. The evidence that pain causes organ complications after surgery is less clear. Neuraxial analgesia with local anaesthetics/opioids and/or α2-agonists, i.v. opioids alone or in combination with non-steroidal anti-inflammatory drugs seems to be the most effective. The benefit of invasive analgesic techniques should be weighed against potential dangers. This is of special importance when considering the use of neuraxial blockade in patients under chronic antithrombotic therapy due to increased potential of a neuraxial haematoma. Patient-controlled analgesia is an alternative for postoperative pain relief. Recent meta-analyses of controlled randomized trials show that patient-controlled analgesia has some advantage with regard to patient satisfaction over nurse-controlled or on-demand analgesia[43]. No difference with regard to morbidity or final outcome was demonstrated. Patient-controlled analgesia is an adequate alternative in patients and situations not suited for regional anaesthesia. Routines for follow-up and documentation of effects should be in place[42, 44-46] Non-steroidal anti-inflammatory drugs and the cyclooxygenase- 2 (COX-2) inhibitors have the potential for promoting heart and renal failure as well as thromboembolic events and should be avoided in patients with myocardial ischemia. The COX-2 inhibitors cause less gastrointestinal ulceration and bronchospasm. The final role for these drugs in the treatment of post-operative pain in cardiac patients undergoing non-cardiac surgery has not been defined. The drugs should be avoided in patients with renal and heart failure, elderly patients, patients on diuretics, as well as patients with unstable haemodynamics [47].

4. Obstetric considerations

Management of pregnancy complicated by aortic stenosis requires an accurate assessment of the severity of the disease. Unlike mitral stenosis, clinical symptoms appear very late in the course of the disease. Once patients complain of angina, shortness of breath, or syncope, their risk of sudden death may be out of proportion to the severity of their clinical symptoms. In the past accurate assessment of the severity of stenosis required cardiac catheterization and significant radiation exposure [48, 49].

Intracardiac pressure gradients cab be accurately measured noninvasively by Doppler echocardiography [50, 51], pressure gradients are calculated by $\Delta P= 4V^2$, where ΔP is the change in pressure and V is the velocity of blood flow determined by Doppler evaluation. Use of the technique has been described in pregnancy, . because pressure gradients are flow-dependant, gradients alone may provide misleading information about the severity of valve narrowing during pregnancy, when cardiac output is increased. In this setting, calculation of aortic valve area provides an index of the stenosis that is independent of changes in transaortic volume flow. Valve area can be determined noninvasively using the Doppler continuity equation [52].

Five principal changes in the cardiovascular system during pregnancy that present unique problems to the parturient with underlying heart disease have been well delineated:

1. 50% increase in intravascular volume that generally peaks by the early to- middle third trimester.
2. Progressive decrease in systemic vascular resistance (SVR) throughout pregnancy, thanks to this mean arterial blood pressure is preserved at normal values, despite a 30%– 40% increase in cardiac output.
3. Marked fluctuations in cardiac output during labour. Pain and apprehension may precipitate an increase in cardiac output to as much as 40%–50% over those levels seen in the late second stage of labour.
4. Each uterine contraction serves as an auto transfusion to the central blood volume, an increase in cardiac output of 10%–25% is seen
5. Hypercoagulability associated with pregnancy and the possible need for appropriate anticoagulation, especially in those patients at increased risk for arterial thrombosis and embolization (prosthetic heart valve).

4.1 General anaesthesia versus other modalities

Improvement of medical and surgical care lead to the decrease in the incidence of rheumatic heart disease and the relative increase in the congenital heat disease in women in the child bearing period. Congenital aortic stenosis is a congenital bicuspid valve leading to valve thickening, subvalvular or tunnel stenosis. In aortic stenosis the coronary blood vessels are distal to the obstruction and are supplied with blood mainly during diastole; in the pregnant state it becomes more difficult to maintain adequate blood flow to the left ventricle because of increasing systolic and end diastolic ventricular pressures. The work of the ventricle is increased and thus it requires a greater coronary artery blood flow; as this cannot be achieved the patient may experience angina and suffer subendocardial ischemia. Regional anaesthesia has been associated with ECG changes of ischemia of multifactorial origin in healthy parturients [53]. The detection of transient ischemia requires capture of ECG data from leads II and V5 and an analysis of changes from control. In spite of the spinal microcatheter technique, colloid infusion and vasopressors intravenously, the patient's systolic blood pressure might decrease. However, it is the diastolic blood pressure which determines myocardial blood flow. The patient with aortic stenosis has a fixed stroke volume and to maintain cardiac output must elevate her heart rate, but this compromises left ventricular filling. The pregnant woman with aortic stenosis is extremely intolerant of change in left ventricular preload. A decrease in preload caused by haemorrhage or associated with regional anaesthesia can produce cardiogenic shock. An increase in preload can precipitate pulmonary oedema. These are acute changes, but they may complicate a more chronic left ventricular hypertrophy which ultimately progresses to congestive cardiac failure. Control over left ventricular preload is less precise with regional techniques because ventilation cannot be manipulated as would be possible with IPPV and filling pressures are less predictable because they depend on fluid load and altered sympathetic nervous system responses. A segmental nerve block from the lowest sacral segment to T4 is necessary by any route to ensure adequate pain relief during Caesarean section and this invariably produces extensive sympathetic block [54]. Moreover, the risk of hypotension cannot be eliminated. Obstetric anaesthetists are agreed that in severe aortic stenosis tachycardia must be prevented, adverse therapeutic events must also be anticipated. If ephedrine is chosen as the vasoconstrictor, it has α and ß effects with a resultant tachycardia which is undesirable in a patient with aortic stenosis. Phenylephrine might be a better choice although it is a pure α agonist [55]. A multidisciplinary approach may be very beneficial in mothers with severe aortic stenosis. The cardiac surgery team in such cases is present during the caesarean section and may take over in case of an emergency [56].

Regardless of the anaesthetic used, blood loss reduces blood volume and to counteract this the uterus contracts and releases additional blood into the circulation. This process is augmented by the use of oxytocin after delivery to ensure uterine contraction and prevent postpartum haemorrhage. One of the deaths reported in the maternal mortality reports describes postpartum cardiac failure exacerbated by oxytocin in a woman with aortic stenosis who required manual removal of the placenta [57]. There is a time and preferably an elective decision, when conversion to general anaesthesia has to be made because of clinical deterioration.

Each patient must be serially assessed during pregnancy by cardiological investigations, including non-invasive Doppler echocardiography and in some cases cardiac catheterisation. The case for general anaesthesia is made on the basis that the avoidance of sympathetic blockade which occurs with regional anaesthesia decreases the risk of significant hypotension following a reduction in systemic vascular resistance. In pregnancy hypotension will compromise not only the maternal myocardium but also the placental blood flow to the foetus. One disadvantage of general anaesthesia is the sympathetic nervous system response to intubation, which can generate tachycardia and hypertension, leading to sudden fluctuations in cardiac output. This can be controlled by induction with a cardio-stable drug followed by a short acting opioid (e.g. alfentanil). Volatile anaesthetic agents also have a direct myocardial depressant effect but this is dose related. In obstetrics, their concentration is limited because of their relaxant effect on the myometrium.

Postoperatively monitoring should continue and it is advised that women with significant cardiac disease should be nursed in a high-dependency unit on the labour ward and cardiac monitoring continued into the puerperium because maternal deaths occur, not uncommonly, 3–5 days postpartum [17]. Postoperative analgesia does not govern the choice of technique for anaesthesia. Patient-controlled analgesia provides satisfactory analgesia after general anaesthesia [58] and by whichever route opioids are administered, respiratory monitoring is required.

4.2 Regional anaesthesia debates

Congenital aortic stenosis has been considered a relative contraindication to pregnancy because of the high maternal mortality (17%) previously reported [59], although this figure has been disputed [60]. The underlying pathophysiology is well known The need to maintain afterload has been extrapolated to suggest that regional analgesia and anaesthesia are contraindicated in pathological states producing a fixed cardiac output.

Authoritative sources state 'high subarachnoid or extradural blockade is contraindicated in patients with cardiovascular disease nevertheless It is possible to provide safe regional anaesthesia for Caesarean section in women with aortic stenosis, but certain conditions must be met.

Firstly, it is essential to identify these women as early as possible in the antenatal period. There is no place for assessing the woman with aortic stenosis a few minutes before she is due to be delivered. Secondly, it is important to make clear written and dated management plans for anaesthesia and delivery in the patient's records. These plans should include provision for emergency delivery and should be amended as necessary during the course of the pregnancy. Regular revision of management plans is important, since deterioration in cardiac status during pregnancy increases maternal risk.

Use of the wedged supine position, or of lateral tilt to ensure displacement of the uterus off the aorta and inferior vena cava, is mandatory during anaesthesia for Caesarean section. It is important to remember that the tilted or wedged position is a compromise between the full lateral position which prevents aortocaval compression and the supine position that the obstetricians would prefer to facilitate surgery. Maintaining the full lateral position until the obstetrician is ready to perform skin incision reduces the risk of haemodynamic instability due to aortocaval compression.

Ultimately there is, of course, no randomised controlled data comparing carefully managed regional anaesthesia with 'cardiac' general anaesthesia for Caesarean section in women with aortic stenosis. All the arguments for and against both techniques are based on anecdotal case reports and assessment of theoretical risks. Multidisciplinary antenatal care of these women is important and should involve senior obstetricians, anaesthetists and cardiologists and regular assessment of cardiac function. Anaesthetic plans for delivery should include provision for the use of invasive monitoring in the peri- and postoperative period and for high-dependency care postoperatively. Both general and regional anaesthesia have significant risks, but incremental induction of either epidural or spinal anaesthesia should be considered a reasonable alternative to general anaesthesia for Caesarean section in the women with aortic stenosis.

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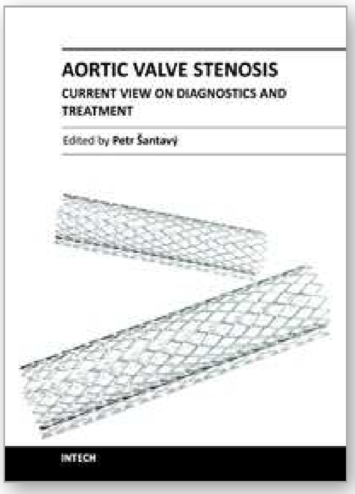

Aortic Valve Stenosis - Current View on Diagnostics and Treatment

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Currently, aortic stenosis is the most frequent heart valve disease in developed countries and its prevalence increases with the aging of the population. Affecting 3-5 percent of persons older than 65 years of age, it makes a large personal and economical impact. The increasing number of elderly patients with aortic stenosis brings advances in all medical specialties dealing with this clinical entity. Patients previously considered too old or ill are now indicated for aortic valve replacement procedures. This book tries to cover current issues of aortic valve stenosis management with stress on new trends in diagnostics and treatment.

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