Higher Isoflurane Anesthetic Dose Associated with Higher E Velocity of Mitral Inflow in CABG Patients

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Abstract

Diastolic Dysfunction (DD) is a well-described component of coronary artery disease (CAD), and is common among cardiac surgery patients.Managed care pressures have intensified recent trends of "fast-tracking" coronary artery bypass grafting (CABG) patients, leading to more reliance on volatile anesthetic gases such as isoflurane. However, volatile anesthetics are known to have the side-effect of depressing myocardial function and possible altering diastolic function.The purpose of this study was to make observations among isoflurane anesthetic use and mitral inflow velocities. Methods: Thirtyelective adult CABG patients were studied after the induction of general anesthesia.No patient was having active symptoms or ischemia. The control group consisted of adult elective CABG patients who did not receive isoflurane, instead receiving a higher dose of fentanyl. Patients studied pre cardio-pulmonary bypass in the low dose isoflurane (0.5-0.99%) group did not have statistically significant changes in E or a velocitiescompared to the control group. Patients in the higher dose range of isoflurane group (1-1.6% Isoflurane) showed a statistically significant greater E velocity, compared to the control group.One possible explanation for the increased E velocity seen in our higher isoflurane groups is that the vasodilating effects of the isoflurane reduced afterload and thus increased the E velocity.

Keywords: Mitral Inflow, diastolic function, diastolic dysfunction, E waves, coronary artery bypass grafting, trans-esophageal echocardiography

1.0 Introduction

Diastolic Dysfunction (DD) is a well-described component of coronary artery disease (CAD), and is common among cardiac surgery patients. (Aurigemma, Gottdiener, Shemanski, Gardin, & Kitzman, 2001; Elesber et al., 2007)Diastolic dysfunction describes a spectrum of altered diastolic cardiac function, including impaired relaxation and decreased compliance.

Approximately half of all patients with overt congestive heart failure (CHF) have diastolic dysfunction while having a normal ejection fraction (EF). (Zile et al., 2001)Furthermore, diastolic dysfunction defined by comprehensive Doppler techniques is common, often not accompanied by recognized CHF, and associated with marked increases in all-cause mortality.(Redfield et al., 2003)

1.1Background

Christian Doppler first describedin 1842 that stars moving toward the earth emitted blue light, while stars moving away from the earth emitted red light. He postulated that the observed frequency of a wave depended on the relative speed of the source and the observer.Relative to sound waves, the phenomena that the pitch of a sound is different for an approaching train whistle than for a train moving away from the observer is familiar to most. In echocardiography, the Doppler technique analyzes the frequency and wavelength of an emitted ultrasound beam. Frequency is defined as the number of waves passing through a certain point in one second, and is a property of the sound waves. It is expressed in units of Hertz (Hz). Hz is important in determining the resolution and depth of penetration of the medium. Doppler assessment of ultrasound waves depends also on the relative change in frequency as the sound waves are reflected back by the moving red blood cells. The frequency of reflected sound waves increases as the red blood cells are moving toward the transducer (and decreases as it moves away from the transducer). This relative shift in frequency is known as the Doppler shift, and allows the echocardiographer to measure the direction, speed, and turbulence of the blood flow. In turn, this allows for quantification of pressures within the heart, as well as assessment of the severity of valvular insufficiency and stenosis.

1.3Doppler Echocardiography is especially important in Measuring Diastolic Function

One component of diastolic function is mitral inflow velocities measured with Doppler transesophageal echocardiography (TEE).(Appleton, Firstenberg, Garcia, & Thomas, 2000; Oh et al., 1997)To measure mitral inflow velocities, Pulse Wave Doppler is used. Pulse wave Doppler allows for the positioning of a pair of cursors, or the “sample volume” precisely where the examiner wants to measure. This is crucial for mitral inflow velocities, because the area intended to be measured is at the tip of the mitral leaflets.

E wave or early phase velocity represents flow during the rapid filling phase while the A wave represents transmittal flow due to the atrial contraction.

1.4Managed Care Pressures Have Intensified Recent Trends of “Fast-Tracking” Coronary Artery Bypass Grafting (CABG) Patients

The term ‘fast-tracking” refers to deliberately tailoring an anesthetic technique to allow for the earlier awakening and thus extubation of patients after CABG surgery. Thus use of “balanced” anesthetic techniques utilizing a variety of anesthetic agents at the same time is supplanting the previous high narcotic based anesthetic techniques for CABGs. While the older high narcotic based technique did not depress cardiac function, it did greatly prolong awakening post operatively, and thus prolonged length of intubation and length of stay in the Intensive Care Unit (ICU). The balanced anesthetic technique introduces more use of volatile anesthetic gases, such as Isoflurane, Desflurane, and Sevoflurane, with lesser amounts of narcotic drugs. These volatile gases are delivered through the oxygen that the patient is ventilated with. However, volatile anesthetics are known to have the side-effect of depressing myocardial function. Thus isoflurane and the other volatile agents might alter cardiac function and diastolic function. Trans-esophageal echocardiography became well established for the detection of coronary ischemia. (3,4,5) New ischemia can be visualized often as a less-contractile segment. This can range from a new mild impairment in wall thickening to a global area of myocardium that is immobile or akinetic. (6) This change in myocardial contractility can be visualized even sooner than EKG changes occur.

There are other etiologies for regional wall motion abnormalities including: infarction, hibernating myocardium, stunned myocardium, bundle branch block, artifact, and a pacemaker. (7,8) While the classic mid-papillary short-axis view of the left ventricle gives a good ‘window’ on the global coronary perfusion and regional wall motion, at the same time, it must be pointed out that not all of the segments are seen in this classic view. Thus, one might still have a significant ischemic area even with normal endocardial motion in the single classic short-axis image.

The purpose of this study was to make observations among isoflurane anesthetic use and mitral inflow velocities.

2.0 Methods

Thirtyelective adult CABG patients were studied after the inducton of general anesthesia with etomidate, fentanyl, and rocuronium. Patients were studied pre cardio-pulmonary bypass only. This eliminated the variables of arresting the heart, cardiopulmonary bypass, and operation on the mitral inflow patterns. No patient was having active symptoms or ischemia. The maintenance phase of general anesthesia was done with oxygen, isoflurane and fentanyl. The control group consisted of adult elective CABG patients who did not receive isoflurane, instead receiving a higher dose of fentanyl. Doppler Trans Esophageal Echo (TEE) measurements were taken with Acuson Sequoia C256 machines using Pulse Wave Doppler with the sample volume positioned at the mitral leaflet tips. E and A wave velocities were measured in meters per second. End-tidal isoflurane concentrations were measured using a DatexCapnomacUltima monitor. Data was analyzed using Chi-Square analysis.

3.0 Results

Table 1: Peak velocity E and A waves by isoflurane dose

Peak Velocity m/sec	Control	Isoflurane 0 .5-.99%	P vs. control	Isoflurane 1-1.6%	P vs. control
E	0.609	0.688	0.11	0.723	0.01
A	0.48	0.554	0.17	0.59	0.25

4.0 Discussion

Patients studied pre cardio-pulmonary bypass in the low dose isoflurane (0.5-0.99%) group did not have statistically significant changes in E or A velocities compared to the control group.

Patients in the higher dose range of isoflurane group (1-1.6% Isoflurane) showed a statistically significant greater E velocity, compared to the control group. This difference was not observed between groups for the A velocity. A variety of factors can influence transmitral flow. Increased preload will increase E velocity, while systolic dysfunction or increased afterload will decrease E velocity.

One possible explanation for the increased E velocity seen in our higher isoflurane groups is that the vasodilating effects of the isoflurane reduced afterload and thus increased the E velocity.

A change in left ventricular relaxation is common in left ventricular hypertrophy as well as in coronary artery disease, and results in a decrease in the velocity and volume of early diastolic filling as well as an increase in the velocity and volume of later diastolic filling linked with atrial contraction. One portion of diastolic function is mitral inflow velocities measured with Doppler Tran esophageal echocardiography (TEE). The E wave or early phase velocity represents flow during the rapid filling phase while the A wave represents trans-mitral flow due to atrial contraction.Diastolic dysfunction is well known to increase with aging.(Hogg, Swedberg, & McMurray, 2004; Zanchetti et al., 2007)As the population ages, DD will be more frequently encountered in patients coming for CABG. (Phillip, Pastor, Bellows, & Leung, 2003)DD is already a frequent co-morbidity among patients presenting for CABG, (Rydberg, Willenheimer, & Erhardt, 2002)

Since DD is known to increase mortality, it is an important factor to understand in our increasingly elderly CABG population.(Aurigemma et al., 2001; Bella et al., 2002) DD has also been shown to predict difficult separation from cardio-pulmonary bypass.(Bernard et al., 2001) Many variables can affect trans-mitral flow velocities. Increased preload will increase E velocity, while systolic dysfunction or increased afterload will decrease E velocity.

4.1Limitations

Limitations of this study: Our present data is only for patients who were studied after induction of general anesthesia, and who were studied pre cardio-pulmonary bypass. This had the advantage of eliminating the variables of arresting the heart, cardio-pulmonary bypass, and operative success. In future studies, it would be useful to also evaluate trans-mitral flow after the CABG surgery, when the patient is off bypass. Further, this preliminary study cannot draw inferences as to cause and effect since it is observational, and not a prospective, randomized study.

4.2Conclusions

Given the increasing use of balanced anesthetic techniques with more use of isoflurane in CABG surgery, understanding the effects of isoflurane on cardiac function and TEE findings is especially important. Even on its own, DD is associated with a greater mortality risk.(Achong, Wahi, & Marwick, 2009) Thus it is important to understand the role that potentially myocardial depressant anesthetic agents could play on affecting DD. This preliminary study shows that patients in the higher dose group of isoflurane (1-1.6%) showed a statistically significantly greater E velocity, compared to the control group.One possible explanation for the increased E velocity seen in our higher isoflurane groups is that the vasodilating effects of the isoflurane reduced afterload and thus increased the E velocity. Our data is only for patients who were studied after induction of general anesthesia, and who were studied pre cardio-pulmonary bypass. This had the advantage of eliminating the variables of arresting the heart, cardio-pulmonary bypass, and operative success. In future studies, it would be useful to also evaluate trans-mitral flow after the CABG surgery, when the patient is off bypass. Further research is needed to better define the effect of isoflurane on diastolic function.

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