Impact of Propofol Anesthesia Induction on Cardiac Function in Low-Risk Patients as Measured by Intraoperative Doppler Tissue Imaging

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Background: Despite a few experimental studies showing a dose-dependent myocardial depressive effect of propofol anesthesia induction, few clinical data are available to determine its precise impact on myocardial function, probably because of its brevity and a lack of appropriate evaluation tools. The purpose of this study was to examine the impact of propofol-based anesthesia induction on left ventricular (LV) function using Doppler tissue and speckle-tracking imaging.

Methods: In 19 low-risk patients with normal LV systolic and diastolic function undergoing noncardiac surgery (all women; mean age, 42 years), propofol bolus (2.0 mg/kg) was administered intravenously for anesthesia induction. LV ejection fraction, global peak systolic longitudinal strain, and tissue Doppler–derived indices of mitral annular velocity during systole (S′), early diastole (e′), and atrial contraction (a′) were determined by intraoperative transthoracic echocardiography before and 1, 3, and 5 min after propofol bolus (T0, T1, T2, and T3, respectively).

Results: The following at T1, T2, and T3 were significantly less in magnitude than at T0: septal S′ (5.61, 5.61, and 5.51 vs 7.60 cm/sec, $P < .001$), lateral S′ (5.75, 5.89, and 5.94 vs 8.12 cm/sec, $P < .001$), septal e′ (10.10, 10.26, and 10.07 vs 11.4 cm/sec, $P < .01$), septal a′ (6.70, 6.21, and 6.13 vs 8.58 cm/sec, $P < .01$), lateral a′ (7.29, 6.81, and 6.85 vs 9.01 cm/sec, $P < .01$), and longitudinal strain (−19.36%, −19.71%, and −19.61% vs −22.28%, $P < .001$). LV ejection fraction was not significantly changed ($P = .361$).

Conclusions: Propofol anesthesia induction diminished LV and atrial contraction in low-risk patients with prior normal LV function. Further studies are needed to understand the clinical implications, particularly for higher risk populations. (J Am Soc Echocardiogr 2013;26:727-35.)

Keywords: Monitoring, Intraoperative, Echocardiography, Doppler, Strain, Propofol

Propofol has become increasingly popular as an intravenous (IV) induction anesthetic because of its favorable pharmacokinetics and pharmacodynamics.[1] Although a few previous experimental studies have speculated on the dose-dependent myocardial depressive effect of propofol,[2,3] the few clinical studies that are available have been unclear about whether it is secondary to load change or a consequence of a direct myocardial depressive effect.[4-6]

The induction phase is a critical step to bring wakeful patients into a sleeplike state in which they are unresponsive to strong adrenergic stimuli, including tracheal intubation and surgical procedures, solely initiated by strong IV hypnotics such as propofol, thiopental, or etomidate. Clinically, it has been a largely overlooked phase because of its short duration and a lack of evaluation tools to detect such presumptive myocardial suppression. As the early detection of myocardial damage from various chemotherapeutic agents has become a topic of great interest,[7] it is important to determine the direct myocardial-compromising effects of this popular induction anesthetic in patients undergoing noncardiac surgery.

Doppler tissue imaging (DTI) is promising for assessing myocardial tissue motion because of its ability to quantify the tissue's higher amplitude, lower velocity signals, and it is regarded as a simple method for noninvasive monitoring to evaluate both systolic and diastolic myocardial function.[8] We believe that real-time intraoperative transthoracic pulsed-wave (PW) tissue Doppler echocardiography may be the proper choice to monitor myocardial function during the anesthesia induction phase. Several previous studies[9-12] analyzed intraoperative PW DTI for determining anesthesia-related effects on left ventricular (LV) diastolic function during the maintenance phase, but none studied the induction phase, which is more critical.

Therefore, using real-time PW DTI, we prospectively analyzed patients without heart disease undergoing noncardiac surgery to explore the hypothesis that anesthesia induction with propofol reduces cardiac function.

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Abbreviations

BIS = Bispectral index

BP = Blood pressure

DTI = Doppler tissue imaging

Ea = Effective arterial elastance

EDVI = End-diastolic volume index

HR = Heart rate

ICC = Intraclass coefficient

IV = Intravenous

LV = Left ventricular

LVOT = Left ventricular outflow tract

P/V = Pressure/volume

PW = Pulsed-wave

SVI = Stroke volume index

2D = Two-dimensional

METHODS

Study Population

After obtaining approval by the institutional ethics committee and written informed consent, we prospectively enrolled adult patients who were scheduled for elective noncardiac surgery. Each patient in the study required the availability of a portable echocardiographic machine and examiner in the operating room, and we selected 19 such patients with low risk, as indicated by a revised cardiac risk index of 0,[13] normal sinus rhythm, normal LV function (ejection fraction $\geq$ 60% and septal e′ $\geq$ 8 cm/sec),[14] and no structural heart disease. Patients with any of the following conditions were excluded in the operating room: unfavorable airway or facemask fit, intractable coughing, hiccups, or hypotension (mean blood pressure [BP] < 60 mm Hg) requiring IV positive inotropes or vasoconstrictors during the study period.

Anesthesia Induction

Upon each patient's arrival at the holding area, we placed an 18-gauge IV line in the right forearm vein and administered 10 mL/kg/h Ringer's lactate solution, 0.2 mg glycopyrrolate, and 0.03 mg/kg midazolam, as premedication. Once in the operating room, we began to monitor the electrocardiogram, noninvasive BP, heart rate (HR), pulse oximetric oxygen saturation, and the bispectral index (BIS). Anesthesia induction was started in the following manner: patients breathed spontaneously with inspired oxygen (8 L/min) through a transparent facemask and a breathing circuit with a reservoir bag. Propofol bolus (2.0 mg/kg) was administered intravenously for 10 sec, after which assisted ventilation followed. After 5 min, complete induction was confirmed by a lack of train-of-four response and followed by tracheal intubation for maintenance anesthesia.

Intraoperative Transthoracic Echocardiography

After positioning the patient supine on the operating table, serial transthoracic echocardiography was performed using a portable Vivid Q platform (GE Healthcare, Milwaukee, WI), before (T0) and 1, 3, and 5 min after (T1, T2, and T3, respectively) propofol bolus injection, along with hemodynamic recordings at the same time (BP, HR, and BIS). Two-dimensional (2D) imaging of parasternal and apical views and PW Doppler imaging of mitral inflow and LV outflow were performed. PW DTI was recorded at both the septal and lateral mitral annulus from the apical four-chamber view to determine longitudinal endocardial velocities, with a sweep speed of 66.7 mm/sec. Each set of images required <30 sec.

On-Board or Offline Analysis

In the operating room, diastolic early (E) and late (A) filling velocities and the deceleration time of E were assessed from the mitral inflow PW Doppler imaging. E velocity is related to the rate of myocardial relaxation and depends on the pressure gradient between the atrium and the left ventricle, and A velocity is related to active atrial contraction. Tissue Doppler–derived indices of systolic (S′), early diastolic (e′), and late diastolic (a′) velocities were measured on board from an average of two or three beats. S′ represents the systolic myocardial velocity above the baseline as the annulus descends toward the apex, timing after isovolumic contraction near the peak LV outflow tract (LVOT) PW signals; e′ represents the early diastolic myocardial relaxation velocity below the baseline as the annulus ascends away from the apex; and a′ represents myocardial velocity associated with atrial contraction (Figure 1).

For offline analysis, LV volume and ejection fraction were determined from 2D images using the modified Simpson's method.[15] The stroke volume index (SVI) was calculated as SVI (mL/m^2) = LVOT area (cm^2) $\times$ LVOT time-velocity integral (cm)/body surface area (m^2), where the time-velocity integral is measured from the apical long-axis view of the LVOT on PW Doppler and LVOT area from the parasternal view of LVOT diameter ($0.785 \times D^2$). The cardiac index was calculated as cardiac index (L/min/m^2) = SVI $\times$ HR/1,000.

Because of limited pressure measurement capability in the left ventricle at the moment of aortic valve closure, systolic BP was used to indicate LV end-systolic pressure.[16] To assess arterial load, total effective arterial elastance (Ea) was calculated as Ea (mm Hg/mL) = systolic BP/stroke volume.[17] To assess load-independent LV function, the pressure/volume (P/V) ratio was calculated as P/V ratio (mm Hg/mL/m^2) = systolic BP/end-systolic volume index.[18,19]

Doppler-independent longitudinal strain was assessed using semiautomated speckle-tracking postprocessing techniques from the 2D apical four-chamber view images at a frame rate of 62.0 $\pm$ 5.0 frames/sec (EchoPAC version 10; GE Healthcare).

Statistical Analysis

The total sample size was calculated as 19 for the repeated-measures analysis of variance, with an effect size of 0.8, $\alpha = 0.05$, and statistical power of 0.8. The effect size was estimated from the variance of S′ in the preliminary echocardiographic data in 20 healthy female patients (the variance explained by an effect of 1.3 cm/sec; error variance, 2.0 cm/sec) using a Web-based statistical program (G*Power version 3.1.5; Franz Faul, University of Kiel, Kiel, Germany).

Statistical analysis for the present study was performed using dBSTAT version 5.0 for Windows (dBSTAT, Seoul, Korea). Baseline and follow-up data are expressed as mean $\pm$ SD for continuous data and as number (percentage) for categorical or binary variables. All continuous data were tested for normal distribution using Kolmogorov-Smirnov nonparametric tests. Sphericity was tested using Mauchly's test. Serial changes were assessed using repeated-measures analysis of variance. Post hoc analyses were performed using Bonferroni's method.

The reliability of measurements was evaluated using the intraclass coefficient (ICC)[20] from a two-way mixed-effects model with absolute agreement. Interobserver variability was tested with another experienced observer, and intraobserver analysis was repeated 4 months after the first analysis. An ICC > 0.80 was considered to indicate good reliability. Two-sided P values < .05 were considered statistically significant.