Assessment of Depth of Anesthesia During Cardiopulmonary Bypass

George Silvay, Jack Nussbaum, Daniel R. Kuni, Philip King, Noeleen Ostapkovich, and Joel A. Kaplan

Department of Anesthesiology
Mount Sinai School of Medicine
New York, New York

Introduction

Despite recent advances in the anesthetic management of patients undergoing open heart surgery (OHS), little is known concerning depth of anesthesia in the presence of variable surgical stimuli.[1,2] The present study was designed to evaluate anesthetic depth during hypothermic cardiopulmonary bypass (CPB) utilizing continuous monitoring of lower esophageal contractility (LEC). Tertiary esophageal contractions are stress related, and their presence during cardiopulmonary bypass may indicate inadequate depth of anesthesia.[3] The responses to inappropriate depth of anesthesia may correlate with increased postoperative morbidity[4] or awareness.[5] The present study was designed to evaluate the depth of anesthesia during hypothermic cardiopulmonary bypass and compare lower esophageal contractility (LEC) with other parameters available to assess depth of anesthesia: mean arterial pressure/perfusion flow/temperature and electroencephalogram (EEG) and somatosensory evoked potential (SEP) measurements.

Materials and Methods

With institutional approval and informed patient consents, measurements were taken on thirty-three adult patients undergoing elective OHS. A radial artery catheter, a peripheral intravenous catheter, and a thermodilution catheter were inserted for hemodynamic monitoring. ECG leads II and V were continuously monitored. Both EEG frequency and SEP latency were recorded using a neurotrac spectral analyzer.[a] Premedication, induction and maintenance of anesthesia were standard.[1] In this communication, we have limited data analysis to the period of the operative procedure related to cardiopulmonary bypass. The data prior to and after perfusion are presented elsewhere.[1]

Direct communications to: George Silvay, M.D., The Mount Sinai Medical Center, Dept. of Anesthesiology, Box 1010, One G.L. Levy Place, New York, NY 10029-6574.

Following endotracheal intubation, a disposable balloon-tipped esophageal probe for the continuous monitoring of LEC was inserted, and the data was displayed and recorded by the Lectron 302.[b] Total LEC activity was calculated as the esophageal contractility index (ECI); ECI = 70 × SLEC + PLEC.[6]

Cardiopulmonary bypass was instituted after administration of heparin and cannulation of right heart for drainage and aorta for return of oxygenated blood. We used the following extracorporeal perfusion systems: Sarns MDX 700 pump system; Oxygenator H 1700 and cardiotomy H 700 F. The system was primed with 750ml NaCl, 750ml 5% dextrose, 50 mEq $NaHCO_3$, 3000 units heparin, 12.5 gm Mannitol, and 25–40 mEq potassium. Temperature of prime in system was 7–10°C. The perfusion flow varied from 1.8–2.4 $1/m^2$ BSA/min according to stage of operation and level of hypothermia.

Results

There were no significant differences in results based on perfusion time, patient age, weight, or length of the surgery. The table shows the number of patients who demonstrated inadequate anesthesia during CPB based on $>20\%\Delta$ of mean arterial pressure; electroencephalogram (spectral edge frequency) $>20\%\Delta$ or SEP latency $>20\%\Delta$; lower esophageal contractility—ECI >50 for three minutes or longer. These data were tabulated according to temperature during cardiopulmonary bypass as well as the anesthetic technique utilized.

The mean values of mean arterial pressure (MAP), spectral edge frequency (SEF), somatosensory evoked potential (SEP), and esophageal contractility index (ECI) are shown in Figures 1–3. The data are presented as functions of time and temperature and are grouped by anesthetic technique. Reference measurements were recorded at sternotomy and sternal closure. Although MAP and SEF remained fairly stable throughout CPB,

a Interspec, Inc., Philadelphia, PA
b American Antec, Valencia, CA

Table 1
Number of patients demonstrating inadequate anesthesia during CPB by hemodynamic, EEG/SEP, or LEC criteria.

	CPB Cooling, Temperature 32–25°C	CPB Temperature <25°C	CPB Rewarming, Temperature 25–32°C
Group A (Isoflurane)	7	3	2
Group B (Fentanyl Bolus)	4	5	4
Group C (Fentanyl Continuous Infusion)	5	2	2

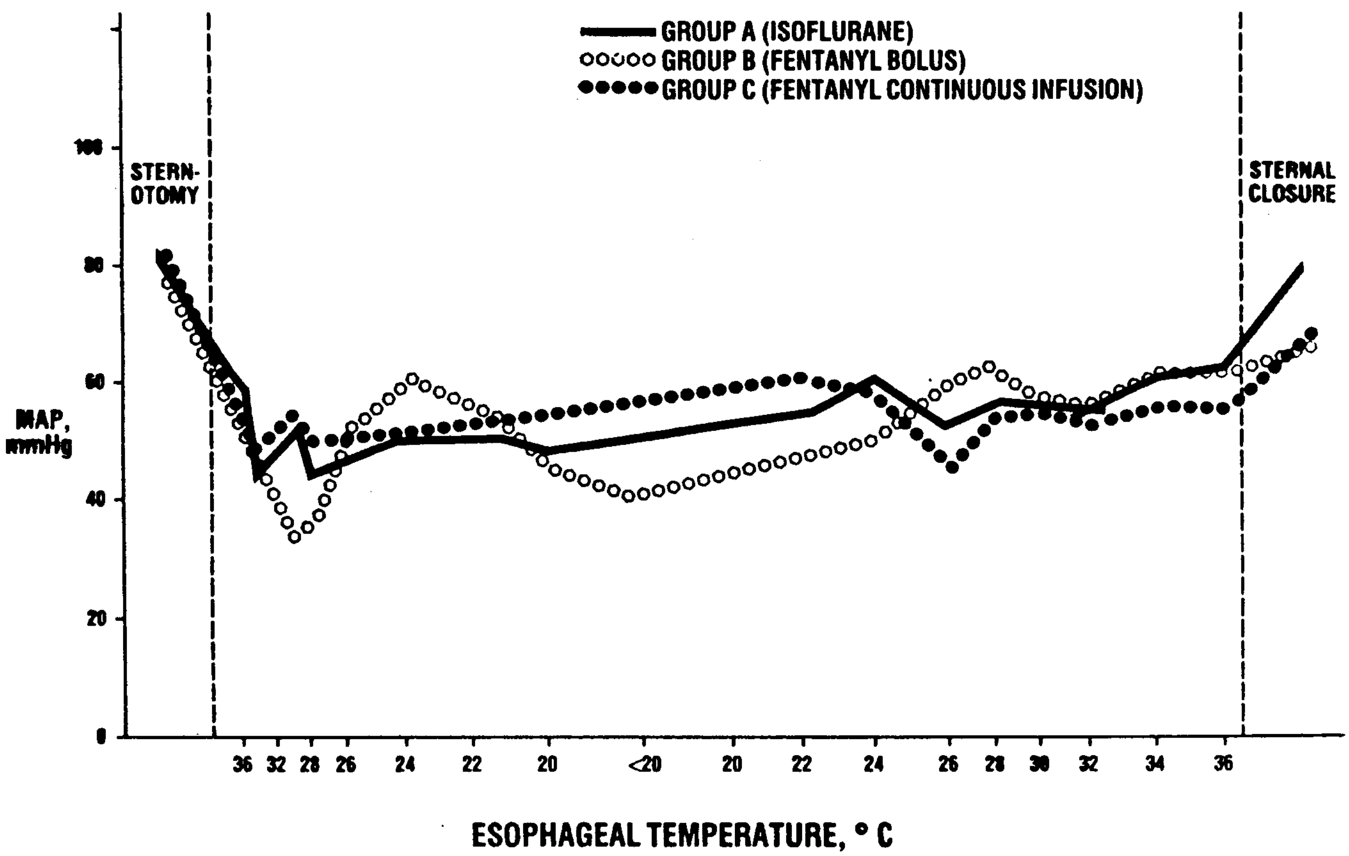

Figure 1. The effect of hypothermic cardiopulmonary bypass on mean arterial pressure (MAP).

both SEP and ECI were highly variable. In particular, ECI was dramatically altered by CPB cooling and CPB rewarming.

Discussion

Cardiopulmonary bypass interferes with the anesthesiologist's and perfusionist's abilities to assess depth of anesthesia. The changes in temperature not only cause a variety of hemodynamic effects, but also change the anesthetic requirements of the patients due to differences in metabolic rate (cooling, rewarming). Hemodilution with the onset of CPB causes changes in the plasma level of administered agents. An increase in mean arterial pressure may be caused by factors other than an inadequate depth of anesthesia, and in this situation the use of additional anesthetic agents is not indicated. However, if inadequate anesthetic depth is the cause of the hypertensive response, lowering the perfusion flow may ameliorate the hemodynamic picture without treating the underlying cause.

The EEG and SEP have been suggested, and in our study were used, as adjuncts in assessing depth of anesthesia. This technique has numerous limitations for every day use. Interpretation of results during various situations is complex and unreliable. Lower esophageal contractility, however, is both accurate and easy to use. The value of continuous monitoring of LEC is particularly important when heart rate and blood pressure are not available or altered by CPB. Our data suggests that an inadequate depth of anesthesia during CPB may be more common than previously appreciated. Measurement of lower esophageal contractility can be used to guide adjustments in the anesthetic management of patients undergoing open heart surgery.

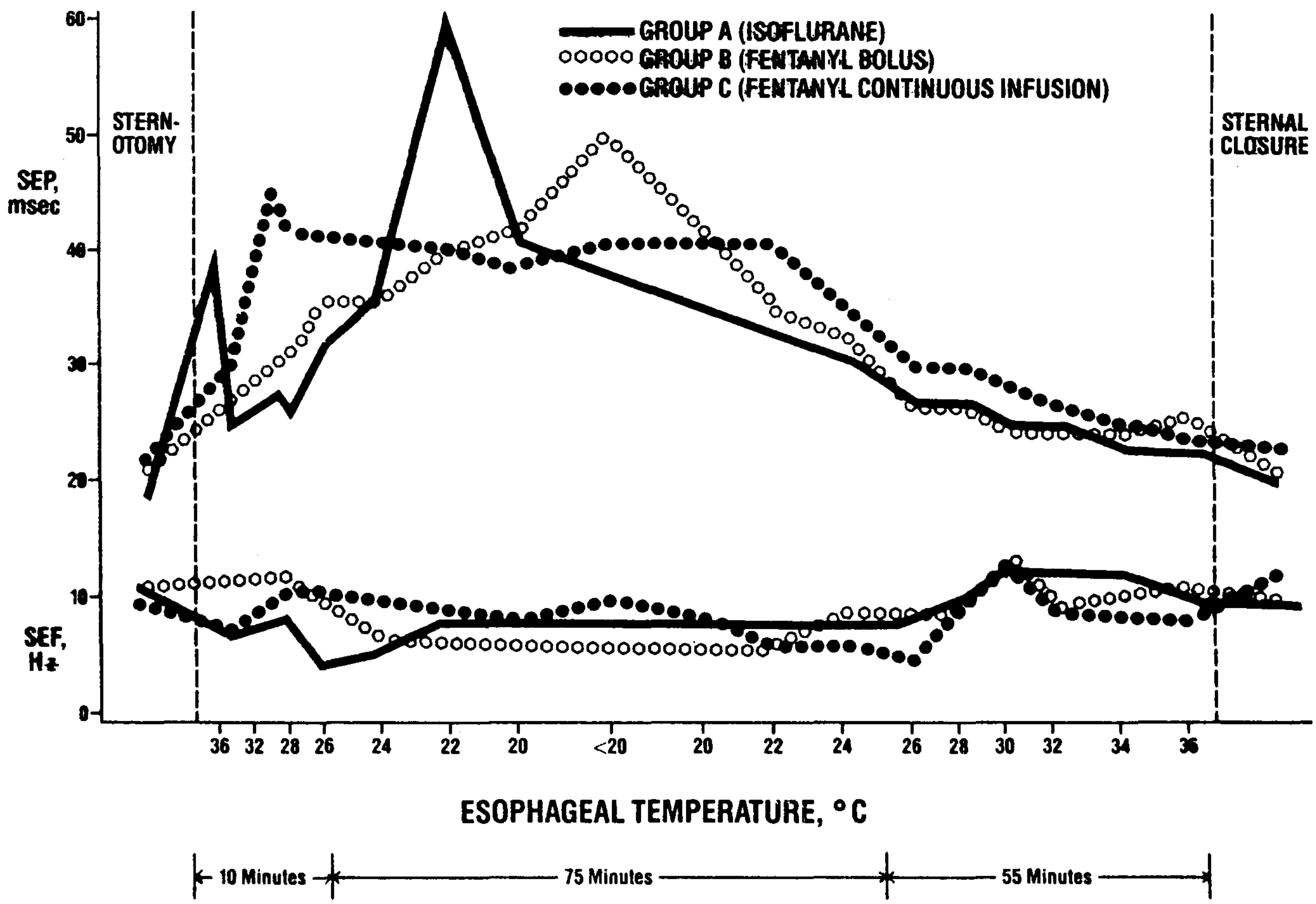

Figure 2. Somatosensory evoked potentials (SEP) and spectral edge frequencies (SEF) during hypothermic cardiopulmonary bypass.

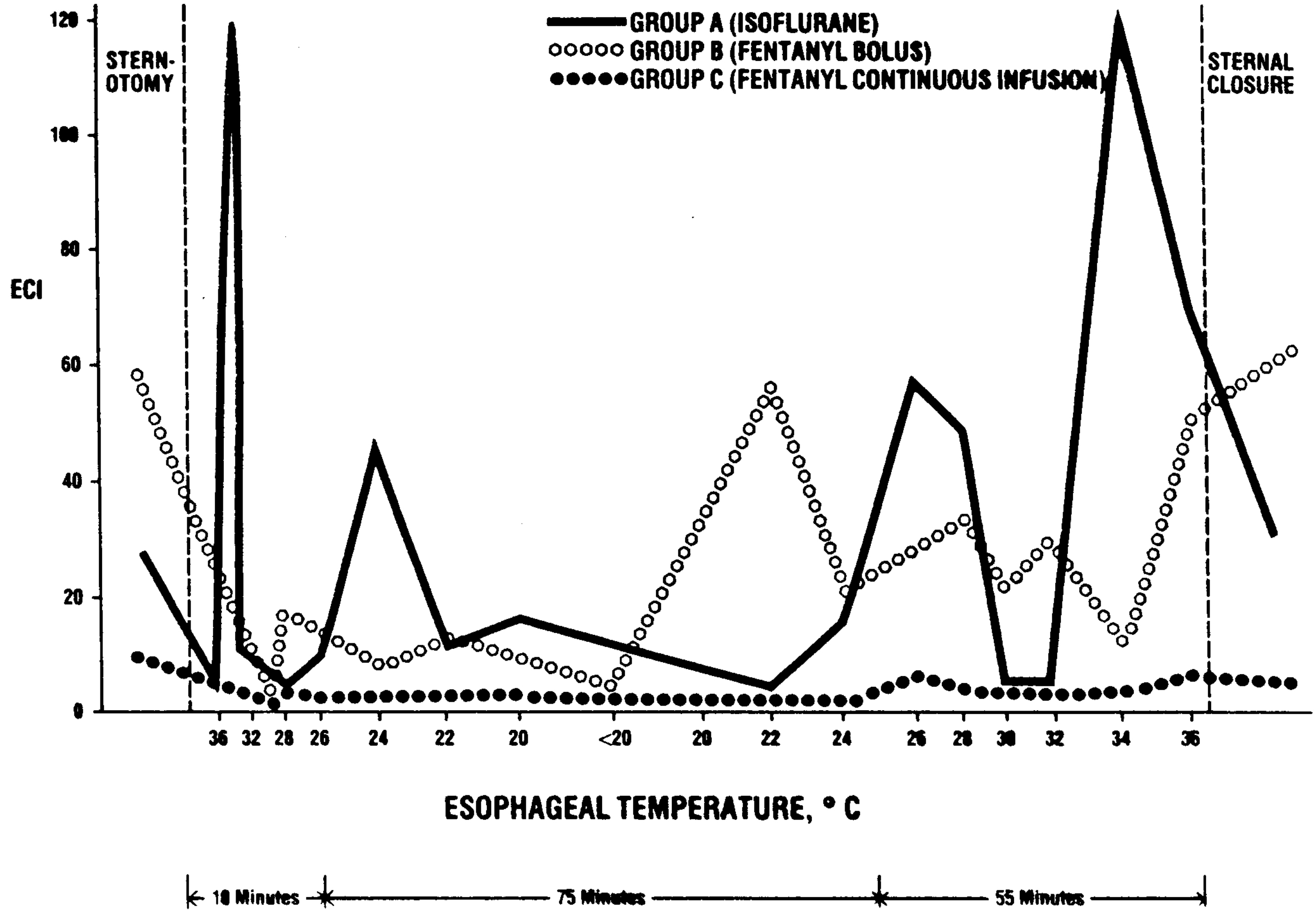

Figure 3. The effect of hypothermic cardiopulmonary bypass on the esophageal contractility index (ECI).

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