ZAHARIA HILLEL, M.D., PH.D.
Assistant Professor

Department of Anesthesiology
The Mount Sinai Medical Center
One Gustave L. Levy Place
New York, New York 10029

REFERENCES

1. Wolf WJ, Neal MB, Peterson MD: The hemodynamic and cardiovascular effects of isoflurane and halothane anesthesia in children. ANESTHESIOLOGY 64:328–333, 1986
2. Murray D, Vandewalker G, Matherne GP, Mahoney LT: Pulsed Doppler and two-dimensional echocardiography: Comparison of halothane and isoflurane on cardiac function in infants and small children. ANESTHESIOLOGY 67:211–217, 1987
3. Mercier JC, DiSessa TG, Jarmakani JM, Nakashini T, Hiaishi S, Isabel-Jones J, Friedman WF: Two-dimensional echocardiographic assessment of left ventricular volumes and ejection fraction in children. Circulation 65:962–969, 1982
4. Schiller NB, Acquatella H, Ports TA, Drew D, Goerke J, Ringertz H, Silverman NH, Brundage B, Botvinick EH, Boswell R, Carlsson E, Parmley WW: Left ventricular volume from paired biplane two-dimensional echocardiography. Circulation 60:547–555, 1979
5. Folland ED, Parisi AF, Moynihan PF, Jones DR, Feldman CL, Tow DE: Assessment of left ventricular ejection fraction and volumes by real-time, two-dimensional echocardiography: A comparison of cine-angiographic and radionuclide techniques. Circulation 60:760–766, 1979
6. Zar JH: Biostatistical Analysis, 2nd edition. Englewood Cliffs, Prentice Hall, 1984, p 313

(Accepted for publication December 3, 1987.)

Anesthesiology
68:646–647, 1988

In Reply:—Thys and Hillel correctly point out that our study, using pulsed Doppler and two-dimensional echocardiography, of the cardiovascular effects of halothane and isoflurane was in infants and small children (mean age = 12 months),[1] while the M-mode echocardiographic study by Wolf *et al.* compared cardiovascular effects of similar end-expired halothane and isoflurane concentrations in older children (mean age = 5.7 yr).[2] This important difference was, indeed, one of the reasons for conducting the study. While it is tempting to state that the cardiovascular differences between the two studies are related to age, we believe that the information derived from the measurement techniques are different and difficult to compare for a number of reasons.

In our study, we used two-dimensional echocardiography to assess ventricular volumes, and pulsed Doppler echocardiography to assess cardiac output and stroke volume. These measurements of myocardial performance were used to determine differences between halothane and isoflurane. Because no direct measures of afterload and only an indirect measure of contractility (ejection fraction) was available in our study, we neither intended nor reported in our paper that pulsed Doppler or two-dimensional echocardiography provided better contractility assessment than M-mode echocardiography. As Thys and Hillel point out, both techniques, M-mode and two-dimensional echocardiography, when used to assess contractility, are affected by loading conditions. Specific conclusions about contractility are difficult to support without measurements of loading. In fact, all *in vivo* attempts at measurement of contractility are limited, to varying degrees, by this problem.

Because we used two-dimensional and pulsed Doppler echocardiography, rather than M-mode, to measure global performance, our paper does not include a full discussion of the reasons why M-mode measurements are limited in the evaluation of left ventricular volumes. Nonetheless, prior clinical studies in older children used M-mode, so our discussion did address some of the methodology differences between these echocardiographic techniques.

The peer-reviewed studies referenced in our paper and those referred by Thys and Hillel *all* conclude that two-dimensional measures are superior to M-mode measurements in assessment of ventricular volumes.[3–5] These comparative clinical studies were in subjects with normal left ventricular function, because it is recognized that M-mode volumes and ejection fractions, unlike those with two-dimensional echo, correlate poorly with angiographic determinations of left ventricular volume in situations of dyskinesia or akinesia.[6,7] The two-dimensional echo technique underestimates ventricular volumes, as we discuss in our paper. For this reason, we added pulsed Doppler echocardiography to measure cardiac outputs and stroke volumes. Ejection fractions were derived by combining the stroke volumes determined by pulsed Doppler echocardiography and left ventricular end-diastolic volumes determined by two-dimensional echocardiography. By this, we believe that we minimized the underestimation of stroke volume. In an editorial that accompanied early M-mode studies during anesthesia, Meyers discussed the limitation of using the cube of a single diameter dimension to assess left ventricular volumes.[6] While M-mode measurements can be used to derive ventricular volume, cardiac output, stroke volume, and ejection fraction by

using regression formulas, as Thys and Hillel state, comparative information about ventricular volumes, ejection fraction, and cardiac output during anesthesia is available from only one[8] of four prior M-mode studies reported in the anesthesia literature.[2,8–10] Therefore, direct comparisons of M-mode derived volumes with our two-dimensional volumes are difficult.

In our study, significant differences between halothane and isoflurane in ejection fraction, stroke volume index, and mean blood pressure were observed only following a fluid bolus. This difference between halothane and isoflurane could have related to a difference in contractility or afterload. Since neither contractility nor afterload could be directly measured, we believe (and so stated) that more studies are necessary before concluding that clinically important differences exist in contractility between equianesthetic concentrations of halothane and isoflurane in infants and small children.

The non-invasive measurements of contractility provided by M-mode techniques, when combined with the more global non-invasive assessments of myocardial performance provided by two-dimensional echocardiography and Doppler echocardiography, may be complementary. If so, then the techniques could be combined to enhance information about the cardiovascular effects of anesthetics. All the echocardiographic methods have limitations that should be understood by readers when interpreting studies using these measurement techniques.

DAVID MURRAY, M.D.
Assistant Professor
Department of Anesthesiology
The University of Iowa
Iowa City, Iowa 52242

REFERENCES

1. Murray D, Vandewalker G, Matherne GP, Mahoney LT: Pulsed Doppler and two-dimensional echocardiography: Comparison of halothane and isoflurane on cardiac function in infants and small children. ANESTHESIOLOGY 67:211–217, 1987
2. Wolf WJ, Neal MB, Peterson MD: The hemodynamic and cardiovascular effects of isoflurane and halothane anesthesia in children. ANESTHESIOLOGY 64:328–333, 1986
3. Folland ED, Parisi AF, Moynihan PF, Jones DR, Feldman CL, Tow DE: Assessment of left ventricular ejection fraction and volumes by real-time, two-dimensional echocardiography: A comparison of cine-angiographic and radionuclide techniques. Circulation 60:760–766, 1979
4. Schiller NB, Acquatella H, Ports TA, Drew D, Goerke J, Ringertz H, Silverman NH, Brundage B, Botvinick EH, Boswell R, Carlsson E, Parmley WW: Left ventricular volume from paired biplane two-dimensional echocardiography. Circulation 60:547–555, 1979
5. Mercier JC, DiSessa TG, Jarmakani JM, Nakashini T, Hiaishi S, Isabel-Jones J, Friedman WF: Two-dimensional echocardiographic assessment of left ventricular volumes and ejection fraction in children. Circulation 65:962–969, 1982
6. Meyer RA: Echocardiography-application in assessing cardiac performance in clinical care. ANESTHESIOLOGY 49:71–78, 1978
7. Schnittger I, Gordon EP, Kritl-Gerald PJ, Pop RL: Standardized intracardiac measurements of two-dimensional echocardiography. J Am Coll Cardiol 2:934–938, 1983
8. Barash PE, Gianz S, Katz JD, Taunt K, Talner S: Ventricular function in children during halothane anesthesia. ANESTHESIOLOGY 49:79–85, 1978
9. Gerson JI, Gianaris LE: Echocardiographic analysis of human left ventricular diastolic volume and cardiac performance during halothane anesthesia. Anesth Analg 58:23–29, 1978
10. Rathod R, Jacobs HK, Kramer NE, Rao TL, Salem MR, Towne WD: Echocardiographic assessment of ventricular performance following induction with two anesthetics. ANESTHESIOLOGY 49:86–90, 1978

(Accepted for publication December 3, 1987.)

Anesthesiology
68:647, 1988

Sir Robert Macintosh—Not MacIntosh

To the Editor:—
Doc EpsteIn's eloquent ink[1]
Lauds outstanding Raymond FInk
With praise, and with prose
That reminds us of those
Like Sir Rob and Ralph Waters
Who in laryngeal quarters
Were joined by Doc Ray
To make an airway.
But Sir Robert might spy
With perceptive i (eye)
An upper case I
Where a lower should lie.

GERALD L. ZEITLIN, M.D.
Department of Anesthesiology
Lahey Clinic Medical Centre
41 Mall Road
Burlington, Massachusetts 01805

REFERENCE

1. Epstein RN: ASA Award: B. Raymond Fink. ANESTHESIOLOGY 67:456–458, 1987

(Accepted for publication December 3, 1987.)