cedures were varied, the assumption that general anes-
thesia was always used for the most major events was not
found. For example, extraction of wisdom teeth, a com-
mon procedure in our study, was approximately equally
dispersed between general and local anesthetic categories.
The immobilization of a fracture in a cast (nil anesthetic)
was not necessarily more traumatic than manipulation of
a fracture and immobilization, although the latter was
performed under general anesthesia. It was these cases,
with surgery performed "remote from the conceptus,"
that allowed the implication of general anesthesia as a risk
factor for abortion.

It is true that an anesthetic and operative experience
may involve a variety of drugs and ancillary exposures.
The cases were studied from a time when the number of
anesthetic agents were limited in Canada, with thiopental,
nitrous oxide, halothane, and narcotics used in most pro-

cedures. The other volatile agents had not yet been re-
leased. We therefore assumed (but could not confirm) a
reasonably uniform standard of drug administration. Un-
fortuantely, we could not obtain information on adjunc-
tive exposures that could have a bearing on outcome. Such
must await prospective studies, which should be based on
defined risks if their enormous cost is to be justified. We
feel we have demonstrated that such a risk does in fact
exist.

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Measured *versus* Predicted Metabolic Rate

To the Editor:—The report by Weissman *et al.*[1] presents
a distorted view of the relationship of measured *versus*
predicted metabolic rates and, as such, dilutes the rec-
ommended use of predicted resting energy expenditures
(REEs) in relation to patient care.

The evaluation of 35 postoperative mechanically ven-
tilated patients (30 measured one time and five measured
two times) who were receiving a wide range of nutrients
both intravenously and intragastrically provides for a weak
argument of the comparison of REE *versus* predicted REE
by the Harris-Benedict equation. In addition, it appears
that the use of the Beckman-MMC1 and the Horizon
MMC carts show different correlations as noted in their
figure 1. Was any patient evaluated using both carts? We
have carried out similar comparisons in a control popu-
lation and found that the variation is less than 4%. The
equation predicts normal REEs; however, it may not be
as exact in some critically ill patients for a number of
reasons.

The various factors that affect REE, both technical and
clinical, have been expounded by the authors, and I wish
to emphasize that the evaluation of REEs is most difficult
when measured during high $F_{I_{O_2}}$. The authors are correct
in suggesting that respiratory quotient (RQ) values that
fall outside the range of 0.67–1.25 are suspect. Even so,
a leak in the system could show up as an artificially in-
creased oxygen consumption with a decreased RQ but
still be in the physiologic range. Therefore, for a com-
bination of reasons, it is not unusual that ventilated pa-
tients with different levels of catabolic drive and different

nutritional intakes show a large variation and can be
somewhat unpredictable. Investigators in this field gen-
erally accept a variation of 10% in REE and believe that
increases in metabolic rates reflect the degree and severity
of injury. Small increases in postoperative patient REEs
may be masked by the variations noted; however, in major
injury, which has been shown to increase REE values by
100%, one would not be concerned if the value were ac-
tually 90–110% when evaluating the patient's nutritional
needs.

Institutions without the capabilities to measure the REE
of patients need guidelines based on predicting REEs with
the Harris-Benedict equation and the tempering of these
calculated values with an activity factor and an injury fac-
tor. This approach might overestimate the needs of some
patients, but it is better than sheer guesswork. There is
nothing wrong with questioning the use of a standard
predicted formula, especially the Harris-Benedict equa-
tion, but when used with the consideration of the nitrogen
requirements of the patient, validity is enhanced. The
intakes of Kcal–nitrogen ratios in the range of 150:1
should reinforce the above estimates. One should also
follow weight changes adjusted for fluid imbalance as an
additional criteria of meeting the energy needs of the
patient. When there is doubt concerning the energy needs
of patients on total protein nutrition (TPN) glucose, it
would be appropriate to decrease the carbohydrate intake
to 50% of the energy needs for the patients with respi-
ratory compromise in order to decrease the CO_2 overload.

As a final comment, the report states that more studies

are needed using direct measurement of REE to allow for a better understanding of the energy expenditures of patients. It is also appropriate to control as many variables as possible when evaluating a given metabolic event. Such quantitative data are rewarding. However, such predictive equations are appropriate in estimating the energy needs of patients whose REE measurements are not possible. It would also be of interest to know how the investigators determined the total daily caloric needs from their quantitative 24-h REE measurement. If they assumed an activity factor with their measured REE, they may be no better off than using predictive equations that hold for normal states.

With these considerations, it seems reasonable to use the data that have been published in terms of general responses of various patient groups and adjusting those requirements on a logical basis (with a consideration of

other parameters such as nitrogen balance) to assure that the clinician is meeting the patient's energy and protein needs on a daily basis.

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REFERENCE

1. Weissman C, Kemper M, Askanazi J, Hyman AI, Kinney JM: Resting metabolic rate of the critically ill patient: Measured *versus* predicted. ANESTHESIOLOGY 64:673–679, 1986

In reply:—We strongly disagree that the article "Resting metabolic rate of the critically ill patient: Measured *versus* predicted" presents a distorted view of the relationship between measures and predicted metabolic rates and, as such, dilutes the use of predicted (resting energy expenditures (REEs) in patient care.

It is important to realize that this paper focuses specifically on the ability of two commonly used predictive equations (Aub-Dubois and Harris-Benedict) to predict REE in critically ill patients. Since these equations are derived from studies performed on normal subjects, it is not unexpected that it is rather difficult to predict accurately the resting metabolic rate of these patients. This is due to the many complex interacting factors that influence these extremely ill patients' metabolic rate. This article thus points out the limitations of predicted metabolic rates in accurately predicting patient needs.

Dr. Long has previously proposed that the caloric intake of patients be estimated by tempering the Harris-Benedict equation with an activity factor and an injury factor. These factors have been derived from studies performed on spontaneously breathing, noncritically ill patients. Whether these recommendations are applicable to intensive care unit (ICU) patients still must be determined. In fact, recent work by our group has found the activity factor in ICU patients to be about 5%.[1] Dr. Long's recommendation is to add up to 20% for activity. Long *et al.* also recommend adding injury factors to the Harris-Benedict equation. These factors are derived from work performed by Kinney[2] and Long *et al.*[3] in patients who were spontaneously breathing and who by and large had

single system disease, for example patients convalescing from total hip replacements, gastrectomies, and cystectomies as well as burn patients. Whether these data are directly applicable to mechanically ventilated, sedated, critically ill patients with multiple system organ failure needs to be determined. It may be that predictive formulae could be used as the basis of estimating the needs of these patients, but more work is needed to determine if and how activity and injury factors are to be added to these formulae. We agree that ideally the effects of the many variables that alter the energy expenditure in critically ill patients should be controlled for. However, practically, that is quite difficult because these patients usually have many intercurrent treatments. It is not uncommon for a mechanically ventilated septic patient to be heavily sedated. Mechanical ventilation and sedation both decrease metabolic rate, while sepsis usually increases but may also decrease metabolic rate.

We agree with Dr. Long that there are many problems with measuring oxygen consumption and carbon dioxide production when elevated oxygen concentrations are being used. We have studied this problem in detail and have developed special validation and calibration procedures.[4] We disagree with Dr. Long's statement that in major injury, REE values are increased by as much as 100%. Only burned patients show such increase, while most studies have shown more modest increases, *i.e.*, at the maximum, 40–50%.

Figure 1 in our article demonstrates the relationship of measured to predicted REE. The reason that the instrument used to obtain each measurement is shown is to