ORIGINAL ARTICLE

ENERGY EXPENDITURE AFTER 2- TO 3-HOUR ELECTIVE SURGICAL OPERATIONS

Andrea Ferreira Schuwartz Tannus, Roberta Loraine Valença de Carvalho, Vivian Marques Miguel Suen, João Batista Cardoso, Nelson Okano and Júlio Sérgio Marchini

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Energy expenditure was measured by indirect calorimetry in 17 adult patients (8 women and 9 men) before surgery, 4 hours immediately after surgery , and 24 hours late after surgery in patients undergoing elective surgery of small-to-medium scope.

Material and Methods: The total duration of surgery ranged from 2 to 3 hours. Repeated measures were performed on the same patient, so that each patient was considered to be his/her own control. All patients received a 5% dextrose solution (2000 mL/day) throughout the postoperative period.

Results: Men showed a reduction in CO2 production during the immediately after surgery period (257±42 mL/min) compared to before surgery (306±48 mL/min) and late after surgery (301±45 mL/min); this reduction was not observed in women. Energy expenditure was also lower in men during immediately after surgery (6.6 kJ/min). None of the other measurements, including substrate oxidation, showed significant differences.

Conclusion: Therefore, elective surgery itself cannot be considered an important trauma that would result in increased energy expenditure. According to this study, it is not necessary to prescribe an energy supply exceeding basal expenditure during the immediate after-surgery period. The present results suggest that the energy supply prescribed during the postoperative period after elective surgery of small-to-medium scope should not exceed 5-7 kJ/min, so the patient does not receive a carbohydrate overload from energy supplementation.

DESCRIPTORS: **Energy expenditure. Indirect calorimetry. Elective surgery of small-to-medium scope. Dextrose solution.**

Energy expenditure varies according to gender, age, nutritional status, physical activity, exposure to cold, emotional stress, and trauma[1]. The metabolic response to surgical trauma has been reported to occur soon after surgery, characterized by a decrease in oxygen consumption, heat production, body temperature, and arterial blood pressure[2]. The late response, observed 24 to 72 hours after surgery, is characterized by increased catabolism, higher oxygen consumption, and protein degradation, with the amino acids being used for gluconeogenesis[3,4]. In these situations, it is recommended that the energy supply be equivalent to the estimated basal expenditure, with 20 to 30% of this value being added as an injury factor[5]. However, elevated glycemia levels and increased CO2 production are often observed in postoperative patients, with the respiratory coefficient being equal or close to 1[6].

The aim of the present study was to measure energy expenditure before surgery (BS), 4 hours immediately after surgery (IAS), and 24 hours late after surgery (LAS) by indirect calorimetry and to compare energy expenditure and consumption of different energy substrates during BS, IAS, and LAS, as well as to determine differences between men and women.

From the Department of Medicine and Department of Surgery, University of São Paulo, Medical School of Ribeirão Preto.

MATERIAL AND METHODS

Patients

Seventeen patients (8 women and 9 men), ranging in age from 18 to 55 years (Table 1), underwent elective surgery of small-to-medium scope, with the total time of surgery ranging from 2 to 3 hours. All patients were evaluated during the 3 periods studied, so that each patient was considered to be his/her own control. Patients with fever, cardiorespiratory diseases, nephropathy, diabetes, or cancer were excluded from the study. All patients underwent herniorrhaphy or cholecystectomy and were anesthetized by caudal block anesthesia. The surgical technical approach, without laparoscopy, was kept constant for all patients.

Experimental design

Clinical data were obtained for each patient on the first day of hospitalization. During their hospital stay, patients were not allowed to smoke or to ingest alcoholic or caffeine-containing beverages. None of the clinical surgical procedures was changed, and the protocol was approved by the Ethics Committee. The following anthropometric data were obtained on the first day: weight (Filizola scale ID-1500, resolution 100 milligrams), height (cm), triceps skinfold (TSk, mm, Lange Skinfold Caliper), arm circumference (AC, cm), biceps skinfold (BSk, mm), and arm muscular circumference (AMC, cm). On the same day, routine laboratory tests, to determine serum glucose, hemoglobin, leucocytes, hematocrit, serum urea and creatinine, serum albumin, and total protein were performed. Basal energy expenditure was measured two days before surgery (BS) (at 8:00 a.m.) after fasting and bed rest for 12 hours, and energy expenditure was again determined 4 (IAS) and 24 hours (LAS) after surgery. Throughout the study, covering the hospitalization and postoperative periods, all patients received by medical indication a 5% IV dextrose solution (2000 mL/24 hours), equivalent to 70 mg glucose per minute, independent of sex or anthropometric data.

Indirect calorimetry

Energy expenditure was determined during a period of 60 minutes by the formula of Weir, i.e., 3.941 x VCO2(L/min) + 1.106 x VO2(L/min) = kcal/min[7], using the factor 4.18 to transform kcal into kJ. Oxygen consumption (VO2) and total carbon dioxide production (VCO2) were determined with a Vmax 29 calorimeter (Sensor Medics Corporation, Yorba Linda, California, USA) using a ventilated-hood system[8]. Steady-state VO2 and VCO2 variation were less than 5%. The gas-analysis system was calibrated every 4 hours with a standard gas sample provided by the manufacturer (cylinder 1: 16% O2 - 3.80% CO2 and cylinder 2: 26% O2 - 0% CO2, under STP).

Glucose and fat oxidation were estimated using equations derived from the formula of Weir, i.e., fat oxidation (g/min) = 1.67 x (VO2 - VCO2) - 1.92 x Nu (g/min) and glucose oxidation (g/min) = 4.56 x VCO2 - 3.21 x VO2 - 2.88 x Nu (g/min)[6,7], where Nu represents urinary nitrogen excretion.

Statistical analysis

Results are reported as mean and standard deviation, and analysis of variance for repeated measures was used to compare the different periods (BS, IAS, and LAS). The level of significance was set at 0.05.

RESULTS

The anthropometric data are shown in table 1. Men were taller than women, but no difference in body mass index was observed. Women showed higher tricipital skinfold values than men, suggesting a larger adipose tissue compartment, with arm circumference being similar in both sexes.

Indirect calorimetry data presented in table 2 showed higher gas volumes and energy expenditure for men during BS compared to women, with a higher respiratory coefficient being observed for women, reflecting the continuous supply of the 5% dextrose solution. Women presented higher respiratory coefficient and carbohydrate oxidation values during IAS and lower fat oxidation. Finally, women showed lower CO2 volumes and, consequently, lower energy expenditure during LAS.

When the different periods (BS *vs* IAS *vs* LAS) were compared, men showed lower respiratory coefficients and expired CO2 volumes during the IAS period, while no difference between periods was observed for women.

DISCUSSION

The main finding of the present study was the lower VCO2 and, consequently, the lower respiratory coef-

Table 1 - Patients anthropometric data.

	Female (8 subjects)	Male (9 subjects)
Age (years)	44±14**	43±16
Weight (kg)	57±15	70±16
Body mass index (kg/m²)	24±6	23±3
Height (cm)	155 ± 5†	171±11
Tricipital skinfold (mm)	24±11†	11±5
Arm circumference (cm)	29±7	28±3
Muscular arm circumference (cm)	21±5	25±3

** Mean ± SD † $p < 0.05$

Table 2 – Indirect calorimetry data for 8 women and 9 men during fasting, and before and immediately/late after surgery receiving a continuous 5% dextrose solution (2000 ml/day).

	Before surgery (BS)		Immediately after surgery (IAS)		Late after surgery (LAS)	
	Female	Male	Female	Male	Female	Male
Volume of oxygen consumption (ml/min)	346±62	246±34*	345±53	272±55	333±76	298±32
CO2 production (ml/min)	228±32*	306±48	250±45	257±42†	246±37*	301±45
Respiratory coefficient (Vco2/Vo2)	0.93±0.10*	0.91±0.06	0.93±0.09*	0.79±0.11†	0.84±0.16	0.88±0.07
Glucose oxidation (g/min)	255±78	248±113	284±103	263±101*	101±157	162±201
Lipid oxidation (g/min)	27±47	63±42	34±45*	123±86	84±83	74±41
Energy expenditure (kJ/min)	5.1±0.1*	7.1±1.1	5.6±1.1	6.6±1.4	6.0±1.4*	7.1±1.2

Statistical significance ($p<0.05$); Mean ± SD; * Female x male; BS: Vco2, Vo2, RQ and Ener; IAS RQ, Gluc and Lip; LAS: Vco2 and Ener; † BS x IAS x LAS; Vco2 and RQ, only for male

ficient observed in men during IAS, although a 5% glucose solution was administered. This finding may be explained by the fact that less glucose was supplied to men per body weight unit. Both men and women received the same total amount of glucose, yet men had higher body weights. On average, men received 0.99 mg and women 1.22 mg glucose/kg/minute. As expected, a decreased glucose supply resulted in a lower VCO2 and glucose oxidation.

On the other hand, the reduction of VCO2 in the expired air observed in men during IAS may also be attributable to hypoventilation[8] or an anesthetic effect[1]. Hypoventilation itself may be due to an anesthetic effect on the central nervous system and/or respiratory musculature (pectoral, diaphragm, and intercostal muscles). These events may increase the arterial CO2 pressure due to the reduced elimination of CO2 by the lungs[9]. Anesthesia may also inhibit the coughing reflex, thus facilitating the accumulation of secretion in the airways which leads to a reduction in alveolocapillary gas exchange[10]. Based on this observation and considering that energy expenditure measured by indirect calorimetry is fundamental for the analysis of O2 consumption and CO_2 production in expired air, anesthesia may alter energy expenditure[11]. General intravenous anesthesia can also result in the blockade of autonomous reflexes acting on the central nervous system, thus reducing general metabolism[12]. However, the type of anesthesia used in the present study, i.e., caudal block anesthesia, does not show any systemic effect, acting only on sensitive and local motor fibers, and thus has a minor effect on body energy metabolism[8,13] .

In the present study, only men showed decreased energy expenditure during IAS. If the lower VCO2 were due to hypoventilation and/or anesthesia, the same effect should have been observed in women, which was not the case. In women, oxygen consumption and CO2 production were similar throughout the study.

As expected, the metabolic rate BS was found to be higher in men than in women, probably due to a higher percentage of lean body mass and, consequently, higher O2 consumption (higher weight observed for men, body mass index similar for men and women, with the tricipital skinfold being higher in women). The lower energy expenditure observed for men IAS may be the result of an adaptive mechanism, preventing a greater loss of lean body mass. During this period, men presented lower glucose oxidation, higher fat oxidation, and a respiratory coefficient of less than 0.8. Another hypothesis might be that women, since they naturally present a larger amount of adipose tissue, also showed a higher resistance to the oxidation of this tissue, in addition to the fact that they received a larger glucose infusion per body mass per minute.

The present study shows that the trauma provoked by surgery of small-to-medium scope lasting 2 to 3 hours was not sufficient to cause hypercatabolism during the first 24 postoperative hours. Therefore, nutritional therapy with an elevated caloric content is not indicated for this period. Energy overload resulting from the increased glucose supply may lead to hyperglycemia, fatty liver, and higher respiratory effort in order to eliminate excess CO2[14] In conclusion, the present results suggest that the calorie supply to patients undergoing surgery of small-to-medium scope should not exceed 5–7 kJ/min, a value similar to that predicted by the Harris-Benedict formula, corresponding to basal energy expenditure, in order to avoid the clinical picture due to glucose overload.

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RESUMO

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TANNUS AFS e col. - Gasto energético após 2 ou 3 horas de cirurgia eletiva. **Rev. Hosp. Clín. Fac. Med. S. Paulo 56**(2):37-40, 2001.

A resposta metabólica ao trauma cirúrgico ocorre imediatamente após a cirurgia e recomenda-se que a oferta calórica, nesta situação, seja igual ao metabolismo basal acrescido de 20-30%, considerado fator de injúria. No entanto, níveis elevados de glicemia e aumento na produção de CO_2 são freqüentemente observados nestas ocasiões .

Objetivo: O principal objetivo do presente estudo foi medir o gasto energético basal, o gasto energético imediatamente e 24 horas após cirurgia eletiva; comparar o gasto e consumo energético entre estes diferentes períodos, assim como, procurar diferenças entre o homem e a mulher.

Material e Método: O método utilizado para avaliar o gasto energético de 17 pacientes adultos (8 mulheres e 9 homens) foi por meio de calorimetria indireta, nos períodos basal, imediatamente após cirurgia e 24 horas após cirurgia . O tempo cirúrgico variou entre 2 e 3 horas. Este foi um estudo pareado , sendo portanto cada paciente considerado controle de si próprio.

Resultados: Todos os pacientes receberam no período pós-cirúrgico solução de dextrose a 5% (2000 mL/dia).Os resultados encontrados nos homens mostraram diminuição da produção de CO_2 no período imediatamente após cirurgia (257±42 mL/min) quando comparado ao gasto energético basal (306±48 mL/min) e 24horas após a cirurgia (301±45 mL/min). O mesmo não ocorreu com as mulheres. O gasto energético dos homens também foi menor no imediatamente após a cirurgia (6,6 kJ/min). Todas outras medidas, incluindo oxidação do substrato, não mostraram diferenças significativas.

Conclusão: Desta maneira, a cirurgia eletiva não pode ser considerado trauma importante que resulte em aumento do gasto energético. Conclui-se que a prescrição energética no pós-cirúrgico, de cirurgias eletivas de médio e pequeno porte, seja equivalente 5-7 kJ/min, evitando desta maneira que o paciente receba sobregarca de hidratos de carbono.

DESCRITORES: **Energia expendida. Calorimetria indireta. Cirurgia de médio e pequeno porte eletiva. Solução de dextrose.**

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