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Ismail S, Nursasmita R. Belitung Nursing Journal. 2017 April;3(2):73-82 Accepted: 24 March 2017 http://belitungraya.org/BRP/index.php/bnj/ © 2017 Belitung Nursing Journal This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International License which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited ORIGINAL RESEARCH ISSN: 2477-4073 COMPARISON STUDY OF ENERGY EXPENDITURE CALCULATION BETWEEN CONVENTIONAL METHOD AND IRETON-JONES METHOD FOR CRITICALLY ILL PATIENT Suhartini Ismail1*, Rizqi Nursasmita2 1Lecturer at Emergency and Critical Care Nursing Division of Adult Nursing Department School of Nursing, Faculty of Medicine, Semarang-Central Java, Indonesia 2Nursing student, Nursing Department, Faculty of Medicine, Semarang-Central Java, Indonesia *Correspondence: Suhartini, S.Kp., MNS., Ph.D Nursing Department, Faculty of Medicine, Diponegoro University. Jalan Prof. H. Soedarto, SH., Tembalang Semarang-Central Java (50275). E-mail: suhartini.ismail@fk.undip.ac.id ABSTRACT Background: The critically ill patients are having nutrition problems in dealing with the critical condition. The problem of nutrition is demanding on the severity of illness. Therefore, the ICU nurses should understand how nutrition can support the patients' recovery. Objective: This study's aim was to compare the result of energy expenditure calculation of conventional method with Ireton-Jones method for critically ill patients in the intensive care unit. Methods: This was a comparative and cross sectional study which recruited 40 samples. The samples were divided into two groups, conventional group method and Ireton-Jones group method, and they met the inclusion criteria. The sample of this

study was determined by convenience sampling. To answer the hypothesis, the hypothesis test used Independent sample t-test. Results: The results revealed that there is no significance difference between energy expenditure calculation conventional method and Ireton-Jones method statically. In the other word, either used the conventional method or the Ireton Jones method, the result of energy expenditure calculation has statically significant difference. Conclusion: It can be concluded that the nurse can use both method to calculate the energy expenditure for critically ill patients to meet their nutrition need. We suggest that for further investigation will recruit many samples and do control of other factors that might be influenced in the study. Key words: energy expenditure, conventional method, Ireton-Jones method, critically ill patients

INTRODUCTION Critically ill patients are a condition who were experienced a critical illness, and in the process of dealing with their ailment required a plethora treatments. The one of treatment was needed including nutrition requirement. Nutrition can be interpreted as a process that people eat some foods which is normally consumed. The nutrition digested in digestive system by absorption, transportation, storage, metabolism, and spending the substances that are not used. The nutrition was used for life, growth, and normal function of organs, as well as to generate energy.1 Patients in the critical care units considered at risk of experiencing nutritional problems.2 Critical care nurses are important in the nutrition therapy because they administer nutritional formulas to critically ill patients.3 The adequate of nutrition intake is determined by the ratio of the amount of energy consumed by the number of nutrient needed.4 The critical ill patients who are admitted to the Intensive Care Unit (ICU) often received inadequate nutrition due to the factor of incorrect prediction of the requirements and due to the late of early giving nutrition.2 Calculation between the needs and the inputs of nutrition can be determined by mathematical equations. The mathematical equations is commonly used to estimate basal energy expenditure (BEE).5 The calculations of energy expenditure such as, Harris- Benedict equation,6 Ireton-Jones,7 and Fick method.8 However, there is no study related to energy expenditure calculation for critically ill patients in Indonesia, particularly in nursing science. The preliminary study found that nutrients calculation that used in the intensive care unit at the hospital is a simple formulation (conventional) that is 25- 30 kcal/kg/day for adults in critically illness. An interesting finding was the health care providers do not clearly understood the formulation come from. This study is firstly conducted in the hospital for calculating and starting provided nutrition for critically ill patients. Ireton-Jones equation calculates by including the patients' state, such as spontaneously breathing or depend on the respirator.9 The main objective in this study was to compare the conventional method of calculating energy expenditure with Ireton-Jones method for critically ill patients in the Intensive Care Unit (ICU) of a central rural hospital in Semarang, Indonesia. We hypothesized our study was the Ireton Jones group will have mean difference compare to the conventional method in the energy expenditure calculation. The results of this study will be as an evidence of

regulatory of nursing service when the nurse does calculation energy expenditure for critically ill patients. The nurses are able to lead and apply the method of nutritional needs calculation, particularly in critical ill patients,4 then the expected Length of Stay (LOS) might be decreased2,10 and the cure of the patients will be decreased. The results of this study also can be used for guidance or initial overview to conduct further research related to the calculation of the nutritional needs for critically ill patients. LITERATURE REVIEW Critical illness increases energy expenditure. Griffith and Bongers in Woodrow suggested that total energy expenditure is 25 kcal/kg/day in severe sepsis and 30 kcal/kg/day in trauma.1 However, increased energy expenditure is often not matched by the body's ability to use energy sources from food. Assessing nutritional needs is a complex task, usually undertaken by dieticians. Hence, the critical care nurse should recognize how assessing and applying the nutrition needs for their patients. There are several physiologic, pharmacologic, and environmental factors that may influence rest energy expenditure (REE) and therefore affect the measurement by indirect calorimetric. Therefore, a standardized, clinical protocol that clearly defines the experimental technique is necessary at any institution to ensure accuracy. Table 1. The advantages and limitations of assessment methods of energy expenditure Method Advantages Limitation Direct calorimetric Highly sophisticated method, considered a gold standard for measuring the total energy expenditure, allows the subject some degree of activity High complexity method, high cost and requires the confinement of the subject for 24 hours or more Indirect calorimetric This method is considered a gold standard for measuring REE and BEE. It is a non-invasive method, reasonably accurate and has a high reproducibility. It also allows to quantify and to identify energy substrates oxidation. Allows short-term measurement of energy expenditure (EE) High cost, relatively complex, requires trained personnel for its correct use. Circulatory indirect calorimetric Practical and simple method. It can be used with caution when there is no other way to access EE in critically ill patients who have already have a thermo-dilution catheter inserted It is invasive. The uses of catheter may contribute to metabolic complications. It is based on instantaneous measurement. Doubled labeled water This a gold standard method which accuracy is 97-99%. It is measures precisely the TEE in free living subjects. It is costly and requires sophisticated equipments as well as trained personnel. It does not provide the information of energy expedited on physical activity neither it gives the information about the substrates oxidation Bioelectrical impedance analysis This an affordable and non-invasive method. It quickly estimates the REE based on its estimation of body compartments including the body fluid distribution considering intra and extracellular spaces. Several factors may influence its result such as hydration state of the subject, prandial/fasting state, exercise, diuretics use, menstrual period, age, ethnicity, body shape or healthy and nutritional condition Sensor of heat and movement Easy and practical use device that estimates EE Studies indicate that the device needs adjust, especially the equation for obese subjects Physical activities records Low cost

method that estimates EE from an extremely detailed registry off all physical activity perform daily Wide variety of types of activities listed. The list is frequently updated which allows the inclusion or the correction of typical activities from specific regions or country The comparison of results between different studies is limited due to various existing codes for activities. The estimated EE does not take into account inter-individual differences which mammy affect the energetic cost of a movement. Dietary questionnaires Simple and affordable method. It can be viable if properly used Subjects can underreport their food intake, which will reduce the accuracy of the method This method is valid only for subjects with stable weight, so in an energy balance equilibrium. Bias can occur because of interferences from the interviewer as well as bias inherent in the chosen method. Predictive equation Simple, fast and affordable method. It can be viable if properly used. It can overestimate or underestimate of the sample population Adapted from Energy expenditure: components and evaluation methods by Volp, P., et al. Nutricion Hospitalaria, 2011. 26: p. 433. It is important to accurately determine energy requirements when formulating a nutrition care plan to prevent the complications of under or overfeeding. In many institutions, standard prediction equations are used to estimate patient's basal energy requirements, and "stress" or injury factors are added, depending on the type and severity of the illness, to estimate total energy requirements.11 However, as will be reviewed, some of these equations were developed for use in healthy individuals, and their use in critically ill patients often results in estimations of energy needs that are off by as much as 30%.9 Therefore, to avoid large errors in estimating energy requirements, it is recommended that energy expenditure be measured in critically ill patients in whom it is technically and clinically feasible Routine intensive care interactions can also alter energy expenditure. Bathing and physical examinations may increase energy expenditure in a critically ill patient up to 20% more than resting values, and chest physical therapy may increase basal needs by 35% restlessness or agitation in the critically ill patient may account for as much as 10% of total energy needs.3,12,13 Although it appears that most activities, including painful procedures such as blood draws affect energy expenditure temporarily, REE is returned to baseline within an hour. However, measurements should be postponed at least 2 hours after a change is made in ventilator settings for the patient to achieve a new steady state.9 Fung also was certain that the medications have an independent effect on REE. Some result in elevations and others in reduction in caloric use. Those that have been shown to elevate energy expenditure are aspirin, in doses commonly used nicotine; and caffeine. Those shown to depress energy expenditure are sedatives and analgesics and of course anaesthesia.9 Furthermore, all measurements should be conducted in a thermo neutral environment, avoiding cool temperatures and drafts, because the normal response to cold may induce shivering thermogenesis.14,15 There are several methods that can be used to predict total energy expenditure for critically ill patients. Each methods had advantages and limitations. Table 1 are presented the methods and their

advantages and limitations. Although the methods had the beneficial and disadvantages, the methods can be used in nursing practice depend on the institution regulation to better outcome of the patients. In conclusion, calculation energy expenditure used Ireton-Jones method was widely used in critical care unit. However, the clinical dilemma appeared which one the energy expenditure equation to use.16 Studies finding on energy expenditure equation was also widely filling the evidence of nutrition issue among critically ill patients. Although, the equation of energy expenditure was existing, the further investigation for nurses is necessary as the nutrition need is responsible of the critical care nurse. METHODS This research is a kind of non- experimental descriptive research with quantitative methods and comparative study with cross-sectional approach. The research was conducted in the Intensive Care Unit (ICU) of central rural hospital in Semarang-Central Java, Indonesia. The inclusion criteria of the samples were 1) aged 18 – 60 years, 2) male and female, 3) and admitted in ICU for 3 – 5 days, and 4) either patients used ventilator or not. To anticipate the number of samples used in this study, researchers used Cohen's method of sample size with a moderate effect size on α = 0.05 and power 0.80 and got the 35 patients finally in each group.17 However, time constraints was a limitation for this study, due to the nature of environment condition and patients' illness, thus there was only 20 patients in each group that the researchers got. The sample of this study was determined by convenience sampling and random approach. The samples then was assigned into two groups by lottery method. Data analysis used descriptive statistic include distribution frequency to analyses demographic characteristics of the patients. Chi-square and Fisher Exact test was used to determine the significance difference between groups from demographic data. Lastly, the hypothesis test used the Independent sample t-test to analysis the mean difference between conventional group and Ireton Jones group. This study was approved by the ethical clearance from the Faculty of Medicine, Diponegoro University and the hospital. In order to require permission from the respondents, the researchers gave the informed consent to the patients directly who were conscious. However, for the patients who were unconscious the informed consent was asked to the family. Anonymity, autonomy, justice, and confidentiality were also concerned in this study in order to meet the ethical consideration. RESULTS Frequency distribution of the study sample is presented in two categories that describe the demographic characteristics and clinical characteristics of respondents. The demographic characteristics of respondents included sex, age, weight, and height, while the clinical characteristic existed classification of BMI (Body Mass Index), ventilator used, and health status. Table 2. Demographic characteristics of respondents and significance differences between conventional group and Ireton-Jones group (N=40) Variables Group (N=20) % Conventional n Ireton-Jones Group (N=20) n % χ2 p Sex Male Female 13 7 61.9 36.8 8 12 38.1 63.2 2,50a 0,11 Age (years) 21-30 31-40 41-50 > 50 3 21 6 10 60 50 50 47.6 2 1 6 11 40 50 50 52.4 0,60b 1,00 Weight (kg) 45-54 55-64 65-74 >75 5 8 4 3 62.5 44.4 40 75 3 10 6 1

37.5 55.6 60 25 2,08b 0,64 Note: a Chi-square; b Fisher's Height (cm) 145-154 155-164 165-175 0 10 10 0 41.7 71.4 2 14 4 100 58.3 28.6 4,77b 0,06 Exact test The results obtained data male was mainly 52.5% (21 respondents), and 47.5% (19 respondents) are female. The distribution of aged mostly aged more than 50 years was 21 respondents (52.5%). In addition, the respondents were in 55-64 kg stayed 18 respondents (45%). Likewise, the distribution frequency of respondents with the height range of 145- 160 cm be located 25 respondents (62.5%) were mainly in this study. Chi-square resulted that there were no difference between conventional group and Ireton- Jones group in the demographic characteristic ($p > 0.05$). The demographic characteristics was presented in table 2. The BMI (Body Mass Index) of the respondents can be classified into 3 categories: underweight was 10% (4 respondents), the normal range was 57.5% (23 respondents), and obese was 32.5% (13 respondents). Samples who used the ventilator support was 32.5% (13 respondents), as well as 67.5% (27 respondents) did not use the ventilator support (Table 3). The health status of the respondents consisting of the patients with skeletal trauma was one respondent (2.5%); mild to moderate infections was 13 respondents (32.5%); abdominal / severe chest surgery and multiple trauma were 6 respondents (15%); closed head injury was only one respondent (2.5%); there are 4 respondent (10%) who diagnosed by sepsis; minor surgery as much as 2 respondents (5%); and congestive heart failure was 7 respondents (17.5%) (Table 3). In conclusion, there were no difference in clinical characteristic between conventional group and Ireton-Jones group. Table 3. Clinical characteristics of respondents and significance difference between conventional group and Ireton-Jones group (N = 40) Variables Conventional Group (N=20) n % Ireton-Jones Group (N=20) n % $\chi 2$ p BMI (Body Mass Index) Underweight Normal Range Overweight 4 11 5 100 47.8 38.5 0 12 8 0 52.2 61.5 4.44b 0.13 Ventilator used Yes No 6 14 46.2 51.9 7 13 53.8 48.1 0.11a 0.73 Note: a Chi-square; b Fisher's Exact test Health Status Skeletal trauma Mild to moderate infections Abdominal/severe chest surgery Multiple trauma Closed head injury Sepsis Hyperthermia/1°C Mild surgery Congestive heart failure 0 7 2 4 1 2 0 1 3 0 53.85 33.33 66.67 100 50 0 50 42.86 1 6 4 2 0 2 0 1 4 100 46.15 66.67 33.33 0 50 0 50 57,14 - - The independent t-test (table 4) obtained that the mean difference of energy expenditure of conventional methods was 1383.8 kcal (SD = 386.13 kcal), while for the mean difference of calculation of the energy expenditure Ireton-Jones method was 1575.4 kcal (SD = 785.94 kcal). The mean value of Ireton- Jones method is greater than the conventional method, this indicates that the average energy expenditure calculated using the Ireton-Jones has a larger calculation. The mean difference between both methods was 131.6. A large standard deviation of the conventional method and Ireton-Jones method is caused by the distribution range of the calculation result as huge variation. Moreover, the conventional method has a minimum value of 500 kcal and a maximum of 2200 kcal, whereas the Ireton-Jones method has a min and max value 69.12 - 3095.04 kcal. Table 4. Mean differences between conventional group and Ireton Jones used

independent t- test (N=40) Group Mean SD t p Conventional Ireton-Jones 1383.8 1575.4 386.13 785.94 - 0.97 0.33 SD = standard deviation; df = 39 In this study, the value of t-test is -0.97 ($p > 0.05$). It can be decided that the hypothesis of differences in the calculated energy expenditure of conventional methods and methods of Ireton-Jones were rejected. In other words, this result show that there is no difference in the results of conventional methods of calculating energy expenditure and Ireton- Jones method. In this study, the value of t-- test is negative value as the average difference between group conventional method and group method Ireton Jones has a greater mean than conventional methods, therefore the results would be statistically tested negative. Although, statically showed there was no significance difference between both groups, clinically the result of the energy expenditure calculation has a difference in result of calories. DISCUSSION The adequacy of nutrient intake was determined by ratio of energy consumed amount by the number of the energy needed.18 The accuracy between the needs and inputs of nutrients can be determined by mathematical equations. Both of the equation of the energy expenditure calculations show that no significance differences. The average differences between both calculation results were only 131.6 kcal. These results were contrary to the researchers' hypothesis in which there were differences in the results of conventional methods of calculating energy expenditure and Ireton-Jones method. Critically ill patients faced the reality of under calories of nutrition. It might be due to the health care provider did incorrect prediction of the nutritional requirements.2 The results of statistical test had shown that there were no significant differences between the conventional methods and Ireton-Jones method. The interesting underlined that the t-test produced a negative t value, as mean of the conventional group is quite smaller than the mean of Ireton-Jones group. This means that the calculation by Ireton-Jones method produces kilocalories greater than conventional methods. The average difference between the two methods should be reviewed considering the provision of nutrients that is overfeeding or re-feeding would influence the healing process of the client.19 The results of another study stated that there were some similarities calculation (difference not significant) of the energy expenditure calculation method.8 Others, including study of Volp, et al18 argued that some methods that used in energy expenditure equation had several advantages and disadvantages. The critical care nutrition20 ruled the predictive equations of REE and indirect calorimetric in patients in the hospital, and found that the most accurate equations was Harris-Benedict method.21 A study by Dickerson and colleagues14 on patients' skin showed that these patients have a variety of hyper-metabolic and energy expenditure cannot be predicted accurately. Even, recently study on energy expenditure is more sophisticated using computerized information system (CIS) to analyse the energy balance in critically ill patients receiving mechanical ventilation. In other words, the energy expenditure equation by any other methods needs more investigation. The critically ill patients should be achieved 3.000-5.000 calories with an assumption that by giving

a greater amount of calories will help a faster healing (hyper-alimentation). The provision of excessive calories will affect complications of carbon dioxide.3,11 The patients who are using ventilator will find difficulties to the weaning and will appear a very hyperosmolar environment, which can cause diuresis osmotic and the disturbances of fluid and electrolyte.12 This study outcome only showed the average calorie intake was 1383.8 to 1575.4 kcal. Definitely, the assumption of calories achievement for the critically ill patients still needed more investigation. The research is strongly influenced by other factors beyond the control of researchers. Another study conducted by the experts mentioned that the estimated rest metabolism rate (RMR) using predictive equation was individually; and they conclude that the records error and certain restrictions on any individual might do when they are into a range of ages and ethnic groups. The study of comparative measurement and prediction of REE should include a variety of clinical factors, such as compliance with medical therapy, weight changes, blood sugar control, dam treatment, which is useful to improve the delivery of clinical nutrients.22 In contrary, no significant difference between the two methods can also be influenced by differences in the number of patients studied population with a population that is used by other researchers. Follow the research of Flancbaum et al, which was the data do not support previous findings showing a strong correlation between REE determined by the Fick method and other prediction equations and indirect calorimetric.8 This study implied that in critically ill patients receiving parenteral /enteral nutrition, indirect calorimetric, if available, remains the most appropriate clinical tool for accurate measurement of energy expenditure. LIMITATIONS In this research, it was found Type II error because this study accepted the null hypothesis. It was because the sample size was too small to make a comparison. In addition, we did not used another tool to score the patients state by APACHE. Therefore the comparison result statistically seem there was no difference. However, Ireton-Jones method was practically answered the total energy expenditure that required for critically ill patients. CONCLUSION Measurements of energy expenditure using conventional methods are not feasible in many clinical settings. In the absence of direct measures or other accurate methods, estimates of energy requirements should be made carefully. Critical care nurses need a better understanding of the tools they use and their limitations. Ultimately, nurse' techniques are likely to be based on those learned during their education and practical training. To improve practice, revision of education guidelines should be a priority. Practice guidelines for the most appropriate methods for estimating energy requirements must be established. These should identify in what situations and for what patients special care and caution is necessary for determining patients' energy requirements. The degree of accuracy that is acceptable must also be determined. This study points towards the identification of two patient groups; one where a universal assessment will be adequate and another where more detailed measurements are required. Prediction equations would only be useful in generating estimates for the former group. For the latter group, more

accurate prediction methods or more practical, validated measurement methods are needed. In either case, steady monitoring and follow-up of patients is crucial to guarantee the provision of adequate nutrition. ACKNOWLEDGEMENT The researchers grateful acknowledge to all respondents who willing to participate in this study. We also extend the appreciation to all critical care nurses in the intensive care unit of the hospital who help and collaborate on this study. The researchers have no conflict of interest for any reason. This research was purely to answer the real phenomena of critically ill patients in the ICU. Both researchers have equal contribution on this study. REFERENCES 1. Woodrow, P., Intensice care nursing a framework for practice 3rd ed 2012, Oxon, USA: Routledge. 2. Barr, J., et al., Outcomes in critically ill patients before and after the implementation of an evidence-based nutritional management protocol. 3. 4. 5. 6. 7. CHEST Journal, 2004. 125(4): p. 1446-1457. Roberts, S.R., et al., Nutrition support in the intensive care unit adequacy, timeliness, and outcomes. Critical care nurse, 2003. 23(6): p. 49-57. O'Leary-Kelley, C.M., et al., Nutritional adequacy in patients receiving mechanical ventilation who are fed enterally. American Journal of Critical Care, 2005. 14(3): p. 222- 231. Volp, P., et al., Energy expenditure: components and evaluation methods. Nutricion Hospitalaria, 2011. 26: p. 430 - 440. Roza, A.M. and H.M. Shizgal, The Harris Benedict equation reevaluated: resting energy requirements and the body cell mass. The American journal of clinical nutrition, 1984. 40(1): p. 168-182. Ireton-Jones, C.S., K.R. Borman, and W.W. Turner, Nutrition considerations in the management of ventilator-dependent patients. Nutrition in clinical practice, 1993. 8(2): p. 60-64. 8. Flancbaum, L., et al., Comparison of indirect calorimetry, the Fick method, and prediction equations in estimating the energy requirements of critically ill patients. The American journal of clinical nutrition, 1999. 69(3): p. 461-466. 9. Fung, E.B., Estimating energy expenditure in critically ill adults and children. AACN Advanced Critical Care, 2000. 11(4): p. 480-497. 10. Rupinder Dhaliwal, R. and D.K. Heyland, Does enteral nutrition compared to parenteral nutrition result in better outcomes in critically ill adult patients? A systematic review of the literature. Nutrition, 2004. 20: p. 843-848. 11. Villet, S., et al., Negative impact of hypocaloric feeding and energy balance on clinical outcome in ICU patients. Jounal of American Dietetic patients. Clinical nutrition, 2005. Association, 2007. 107: p. 393-401. 24(4): p. 502-509. 19. Drover, J.W., et al., Nutrition 12. Kan, M.N., et al., Estimation of Therapy for the Critically Ill Surgical energy requirements for mechanically Patient: We Need To Do Better! ventilated, critically ill patients using Journal of Parenteral and Enteral nutritional status. Critical care, 2003. Nutrition, 2010. 34(6): p. 644-652. 7(5): p. R108. 20. Critical Care Nutrition. Indirect 13. Sole, M.L., D.G. Klein, and M.J. Calorimetry vs. Predictive. 2011 Moseley, Introduction to Critical [cited 2011 January 15]; Available Care Nursing. . 5th ed2009, St. Louis, from: Missouri: Saunder. http://www.criticalcarenutrition.com/i 14. Dickerson, R., et al., Accuracy of ndex.php?option=com_content&view predictive methods to estimate resting =category&layout=blog&id=21&Ite

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