Journal of Aging Research & Clinical Practice©
Volume 1, Number 3, 2012

BODY MASS INDEX ESTIMATION ON GASTROSTOMY PATIENTS USING THE MID UPPER ARM CIRCUMFERENCE

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Abstract: *Introduction/aim:* Body Mass Index (BMI) portrays nutritional status through the equation Weight/Height^2. In Endoscopic Gastrostomy (PEG) patients, BMI is easy to determine when gastrostomy is performed. As the disease progresses, patient becomes bedridden, BMI becomes problematic to evaluate. In PEG-patients, we compared estimated BMI values obtained through Mid Upper Arm Circumference (MUAC) and regression equations described by Powell-Tuck/Hennessy (BMIPTH) with values from Weight/Height^2 (BMIQI), in order to assess whether those equations could estimate the BMI in an equivalent way. *Patients/Methods:* In an adult PEG-patients retrospective study, we computed BMIQI and BMIPTH at date of gastrostomy. BMI (BMIQI and BMIPTH) was sorted into 3 categories: underweight (<18,5 Kg/m^2), normal (18,5-24,9 Kg/m^2), overweight/obesity (> 25 Kg/m^2). BMIQI and BMIPTH were compared, first globally, and then according to gender and age (≥65/<65). *Results:* From 157 patients (124 males), aged 20-89 years, most were in normal BMI range. BMIQI and BMIPTH placed most patients in the same categories. There was no statistically significant differences between BMIQI (mean: 20,55±4,34) and BMIPTH (mean: 20,29±4,13). Similar results were obtained in gender and age analysis. *Conclusion:* Values obtained by MUAC and Powell-Tuck/Hennessy's regression equations were equivalent to Weight/Height2. These equations can be an alternative for PEG bedridden patients.

Key words: Body Mass Index, BMI, Mid upper arm circumference, MUAC, Gastrostomy, PEG.

Introduction

Enteral nutrition (EN) is a recommended nutritional support method for patients whose oral intake is insufficient to match their nutritional needs (1, 2) but whom, in spite of this, still have an efficient digestive tract, able to digest and absorb nutrients (3).

In dysphagic patients, percutaneous endoscopic gastrostomy (PEG) is the gold standard for long term enteral feeding, usually for periods longer than 4 weeks (1, 4, 5). As a general rule, PEG feeding is considered when the patient's nutritional intake is insufficient from a quantitative and/or qualitative point of view (2). Neurological disorders, head and neck cancer and upper esophageal cancer are the most common causes leading to deficient oral intake (6-8). In most cases, PEG feeding is able to reverse the catabolic process, prevent weight loss and maintain the nutritional status (9-11).

PEG patients are often bedridden, frequently presenting speech and motor impairments. The usual nutritional assessment tools are not appropriate to evaluate most of these patients and EN teams must rely on anthropometric and laboratory data (12). Being practical, non-invasive and inexpensive, many different anthropometric parameters have been developed and used worldwide, becoming useful means to assess malnutrition (13-15).

The most widespread method is the Body Mass Index (BMI), also called Quételet's Index, created by Lambert Adolphe Quételet (16, 17). This Index was designed as a way of depicting the nutritional status through the division of the weight, in kilograms, by the square of the height, in meters (BMI = Weight/Height^2) (17, 18). In practical terms, BMI is extremely useful due to its simplicity. Nevertheless, it has some limitations: 1) its relationship with the body proportions, since some people with short lower limbs, considering their height, will have an increased BMI; 2) its relationship with muscle mass, particularly in males, as athletes and individuals with a higher percentage of muscle may be included in an obesity level BMI (19, 20). Since this index is unable to tell overweight resulting from an increase in adiposity and the one resulting from an increase in muscle mass or an edema apart, the BMI should be combined with other methods (18, 19).

During a PEG patient's first clinical and nutritional assessment, it is often possible to determine their weight

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Received February 22, 2012
Accepted for publication April 19, 2012

and height, in order to estimate the BMI. However, as underlying illnesses progress, patients become bedridden and their weight becomes difficult to obtain. In order to screen and monitor these patients, a different way to determine the BMI on individuals who are unable to stand up, without using weight or height, but whose results could be overlapped to the BMI, would be most useful.

By using a sample of over 1500 patients, Powell-Tuck & Hennessy decided to investigate the nutritional status' anthropometrical assessment by comparing the mid upper arm circumference with the BMI and with the percentage of weight loss21. With this study they were able to identify a correlation between the mid upper arm circumference (MUAC) and the BMI. Even though the former classified a larger number of patients as being undernourished, they claimed that the MUAC values calculated for age and sex and appropriate to the BMI cut off points could be used as a useful measurement in assessing the nutritional status of patients. Being so, they defined two regression equations that correlate the mid upper arm circumference with age, while accounting for the patient's sex (21):

For men:

$BMI = 1{,}02 \times MUAC + 0{,}03 \times Age - 6{,}7$, $P < 0{,}0000$ ($R2 = 0{,}77$)

For women:

$BMI = 1{,}10 \times MUAC + 0{,}023 \times Age - 8{,}0$, $P < 0{,}0000$ ($R2 = 0{,}76$)

This measure may have important benefits, for it is easy and fast to obtain, it does not require expensive equipment and it does not force the patient to move. In bedridden patients this could be a way of comparing the present BMI with their former BMI records, obtained when the patient could easily be weighted.

In clinical practice, these equations have sometimes been used as a way of obtaining the BMI, even though they have not been validated in this specific clinical context.

In PEG patients, we intended to compare the estimated body mass values obtained through the MUAC and the regression equations described by Powell-Tuck & Hennessy (BMIPTH) to the ones obtained using the equation described by Quételet (BMIQI) in order to assess whether those two methods could estimate the BMI in an equivalent way. If this proves to be true, EN teams could use the Powell-Tuck & Hennessy regression equations during the follow-up of PEG patients, when the underlying diseases progress, patients become bedridden and their weight becomes difficult to obtain, and compare BMIPTH with BMI values previously obtained with the classical $Weight/Height^2$.

The present study has two major limitations: It is a retrospective study and the comparison was limited to one moment, the day of gastrostomy, for each patient.

Patients and Methods

Using the clinical records of our Enteral Nutrition Team, we performed a retrospective study on PEG-patients. Using their clinical and nutritional assessment, recorded at the date of the endoscopic procedure, we selected 157 adult patients, from both genders, that had been submitted to a PEG. Inclusion criteria were:

(1) Age ≥ 18 years.

(2) Complete clinical records, including: age, sex, height, weight and mid upper arm circumference values.

Patients that had incomplete records were excluded.

Their weight was obtained using a KERN® electronic calibrated scale. The patients were weighted with their shirt, socks and underwear, and standing up. The weight was registered in kilograms, to one decimal place, with an error of 0,05 Kg.

The patient's height was measured in an orthostatic position, with their feet together, their knees straight and their head aligned according to the Frankfort horizontal plane, registered in meters and rounded to tenths, with an error of 0,05 cm.

The patient's mid upper arm circumference (MUAC) was measured with the patient sitting or lying down, by identifying the non-dominant arm's middle section, between the acromion and the olecranon, without compressing the tissue (22). For this procedure, an extendable measuring tape was used, with the arm's perimeter being registered in centimeters, with an error < 0,05 cm. Patient's individual limitations and clinical settings were taken into account when obtaining MUAC measurements, namely in stroke and other neurological patients, where the non-affected arm was chosen.

The BMIQI was calculated using the following expression computed by Quételet: $BMIQI = Weight(Kg)/Height(m)^2$. The BMIPTH wa s determined by using the regression equations described by Powell-Tuck & Hennessy: for men, $BMIPTH = 1{,}02 \times MUAC + 0{,}03 \times Age - 6{,}7$ ($p < 0{,}0000$; $r2 = 0{,}77$), for women, $BMIPTH = 1{,}10 \times MUAC + 0{,}023 \times Age - 8{,}0$) ($p < 0{,}0000$; $r2 = 0{,}76$).

In order to classify the sample about its nutritional status at the time of PEG placement, the BMI (BMIQI and BMIPTH) was sorted into 3 categories: underweight (< 18,5 Kg/m^2), normal range (18,5-24,9 Kg/m^2), overweight/obesity (> 25 Kg/m^2). Patients were first analyzed globally, and then according to subgroups, by gender and by age group, elderly (≥65 years) and non-elderly (<65 years).

Statistical Analysis

The statistical analysis was performed using the Statistical Package for the Social Sciences – SPSS® - SPSS, version 17.0 software. In order to analyze the main

features of the sample under study, descriptive statistics were used by calculating the means and the standard deviation. We managed to analyze the variables distribution using the Kolmogorov-Smirnov normality test. The Paired Samples t-test was used to understand if the BMIQI and the BMIPTH had meaningful differences. Pearson correlation coefficient (r) and the significance level (p) were calculated using the study's variables. A p-value below 0,05 was considered to be statistically significant.

Results

Patients

Of the 157 PEG-patients that were the sample under study, 79% of them were men (n = 124) and 21% were women (n = 31). The patients' age ranged between 20 and 89 years old, with a mean age of 61,2 years ± 13. For the study, the sample was divided by age group, with 35,7% of them being elderly (n = 56), 65 or older, and 64,3% being non-elderly(n = 101), with ages below 65. According to their dysphagia-leading illness, 65% had head and neck cancer (n = 102), and 35% suffered from neurological disorders (n = 55).

Global Analysis

By the time of the gastrostomy procedure, the sample (n =157) had an average BMIQI ± standard deviation of 20,55 Kg/m2 ± 4,34 and a BMIPTH of 20,29 Kg/m2 ± 4,13. The parameter's descriptive analysis is presented in Table 1.

Table 1
Patient's characteristics: Descriptive Analysis

Parameters	Average ± Standard Deviation
Age	61,24 ± 13,06
MUAC	24,60 ± 3,88
BMIQI	20,55 ± 4,34
BMIPTH	20,29 ± 4,13

A positive correlation between the BMIQI and the BMIPTH was found (r2=0,756). No statistically significant differences were found between the obtained values (p=0,288).

Concerning the nutritional status, about 1/3 of the sample presented a BMI<18,5. The distribution in the 3 BMI categories was equivalent using either the BMIQI or the BMIPTH (Table 2). Most of the patients were within the normal range, followed by the people in the underweight category and finally by overweight or obesity. The regression equations of Powell-Tuck & Hennessy identified four patients more as underweight (2,5%), two more within the normal range (1,3%) and less 6 as overweight or obese (3,8%).

Table 2
BMI categories

Categories (n = 157)	BMI QI Frequency (%)	BMI PTH Frequency (%)
Underweight	48 (30,6%)	52 (33,1%)
Normal Range	87 (55,4%)	89 (56,7%)
Overweight/Obesity	22 (14%)	16 (10,2%)

Gender Analysis

Grouping the sample by gender, the mean BMIQI for men was 20,38 Kg/m2 ± 3,83 and the mean BMIPTH for the same sex was 20,19 Kg/m^2 ± 3,54. Analyzing the same parameters above for women, the mean BMIQI was 21,15 Kg/m^2 ± 5,89 and BMIPTH was 20,67 Kg/m^2 ± 5,88. Alike the global analysis, no statistically significant differences were found between the values obtained for men and for women (Table 3).

Table 3
Gender: Paired Sample t-test

	BMIQI Average ± Standard deviation	BMIPTH Average ± Standard deviation	p value
Men	20,38 ± 3,83	20,19 ± 3,54	p = 0,431
Woman	21,15 ± 5,89	20,67 ± 5,88	p = 0,478

Age Group Analysis

Splitting the patients by age group, in the elderly the mean BMIQI was 21,44 Kg/m^2 ± 4,65 and the mean BMIPTH was 21,25 Kg/m^2 ± 3,99. In the non-elderly, by analyzing the same variables, the mean BMIQI was 20,05 Kg/m^2 ± 4,09 and the mean BMIPTH was 19,76 Kg/m^2 ± 4,12. No statistically significant differences were found, both in elderly and in non-elderly, between the BMIQI and the BMIPTH (Table 4).

Table 4
Age: Paired Sample t-test

	BMIQI Average ± tandard deviation	BMIPTH Average ± Standard deviation	p value
Elderly	21,44 ± 4,65	21,25 ± 3,99	p = 0,700
Non-elderly	20,05 ± 4,09	19,76 ± 4,12	p = 0,252

Discussion

The BMI is a conventional way to assess the nutritional status, and its main features are simplicity and the ability

to evaluate, with some precision, the nutritional status in which the patient is in (19). The BMI equation, which correlates the weight in kilograms with the square of the height in meters, cannot be easily used on bedridden patients. Being so, it is clear that special nutritional assessment methods have to be developed for these patients (23). The lack of investigation in this area has made this study pertinent, since it aims to compare the Body Mass Index, calculated by Quételet's formula, with the values obtained by the regression equations defined by Powell-Tuck & Hennessy to check if these could estimate the BMI in an analogous way in PEG-patients. These regression equations, developed by Powell-Tuck & Hennessy, could be valid alternatives to the BMI that is determined by Height/Weight^2, as they use the patient's mid upper arm circumference, gender and age, easily obtained parameters.

Globally, we could verify that the distribution in the 3 BMI categories was similar using either the BMIQI or the BMIPTH. Both of them could identify that most of the sample was within the normal range, followed by people in the underweight category and finally by overweight or obesity. In comparison to Quételet's Index, the regression equations proposed by Powell-Tuck & Hennessy only identified 2,5% more patients as being underweight (n = 4), 1,3% more as being within the normal range (n = 2) and 3,8% less as being overweight or obese (n=6). It is possible that the BMIPTH slightly underestimates the BMI, since it has been shown to be more sensitive in identifying underweight patients than ones with greater weight. This fact had already been noted by Powell-Tuck & Hennessy, who stressed that the mid upper arm circumference seemed to be more fit in evaluating underweight patients (21). Also for being more adapted to low weight patients, these equations may be adequate to PEG-patients, who, as a group, tends to be underweight.

Clearly, the present study has some limitations. PEG-patients are an heterogeneous group in respect to the underlying diseases and moment of gastrostomy in each disease evolution. Our study evaluated only a group of Portuguese PEG-patients from a single center. There was no longitudinal evaluation since many of our patients become bedridden shortly after the gastrostomy procedure. Larger, multicenter and longitudinal studies are needed to confirm our results. Nevertheless, the absence of statistically significant differences in our sample, globally, by gender and by age, suggests that the values obtained through Powell-Tuck & Hennessy's regression equations are able to estimate the BMI in a comparable way to the one calculated through Weight/Height^2, in the heterogeneous and very demanding group of gastrostomy patients.

Conclusion

In our study with 157 PEG-patients, the values that were obtained by Powell-Tuck & Hennessy's regression equations are analogous to the ones obtained with Quételet's Index, suggesting that these regression equations can be used as an alternative for PEG patients that, as their underlying illnesses progress, became bedridden and unfit to be weighted.

References

1. Stroud M, Duncan H, Nightingale H. Guidelines for enteral feeding in adult hospital patients. Gut 2003;52(Suppl VII):vii1–vii12.
2. Loser C, Aschl G, Hebuterne EMH, Mathus-Vliegen M, Muscaritoli, Niv Y, Rollins P, Singer RH,. ESPEN guidelines artificial enteral nutrition – Percutaneous endoscopic gastrostomy (PEG). Clin Nutr 2005; 24:848-861.
3. Pearce C.B, Duncan H.D. Enteral feeding. Nasogastric, nasojejunal, percutaneous endoscopic gastrostomy, or jejunostomy: its indications and limitations. Postgrad Med J 2002;78:198-204.
4. Moller P, Lindberg G-G, Zilling T. Gastrostomy by various techniques: evaluation of indications, outcome, and complications. Scand J. Gastroentrol 1999;34:1050-4.
5. Nicholson FB, Korman MG, Richardson MA. Percutaneous Endoscopic Gastrostomy: a review of indications, complications, and outcomes. J. Gastroenterol Hepatol 2000;15(1):21-5.
6. Sanders DS, Leeds JS, Drew K. The role of percutaneous endoscopic gastrostomy in patients with dementia. Br J Nurs. 2008;8-21:17(9):588-94
7. Stripf T, Lippert BM. Nutrition in patients with head and neck cancer. Laryngorhinootologie 2005;84(10):758-64;765-6.
8. Fonseca J, Santos C. Clinical data, evolution and survival of 200 consecutive PEG patients. Clin Nut 2009;4(2)Suppl:122.
9. Fietkau R, Sailer D, Sauer R et al. Percutaneous endoscopically guide gastrostomy in patients with head and neck cancer Cancer Rev 1991; 121: 269-82.
10. Wasiak J, Cleland H, Jeffery R. Early versus late enteral nutritional support in adults with burn injury: a systematic review. J Hum Nutr Diet 2007;20(2):75-83.
11. Gauderer M.W.L. Percutaneous Endoscopic Gastrostomy – 20 years later. A Historical Perspective. J Ped. Surg 2001; 36: 217-219,
12. Santos C. Gomes C, Fonseca J. Low serum cholesterol is associated with poor outcome of PEG patients. Clin Nut 2011:6(2)Suppl:73.
13. Onnis M, Habicht JP. Anthropometric Reference data for international use: recommendations from a World Health Organization Expert Committee. Am J Clin Nutr 1996:64(3):650- 8.
14. Lukaski H. Methods for the assessment of human body composition: traditional and new. Am J Clin Nutr 1997;46:537-56.
15. Butters M, Straub M, Kraft K, Bittner R. Studies on nutritional status in general surgery patients by clinical, anthropometric, and laboratory parameters. Nutrition 1996;12(6):405-10.
16. Eknoyan G. Adolphe Quetelet (1796–1874) - the average man and indices of obesity. Nephrol. Dial. Transplant 2008; 23 (1): 47-51.
17. Garrow JS & Webster J. Quetelet's Index (W/H2) as a measure of fatness. International Journal of Obesity 1985;9:147-153.
18. Kathy Hammond. Assessment: Dietary and Clinical Data. In: Escott-Stump S, Mahan L. Krause's food, nutrition & diet therapy. Saunders ELSEVIER. 12th edition 2010. Chapter 14; p. 383-409
19. Gallagher D, Heymsfield SB, Heo M, Jebb SA, Murgatroyd PR, Sakamoto Y. Healthy percentage body fat ranges: a approach for developing guidelines based on body mass índex. Am J Clin Nutr.2000;72(3),694-701.
20. Seung Wan Ryu, In Ho Kim. Comparison of different nutritional assessments in detecting malnutrition among gastric cancer patients. World J Gastroenterol 2010;14;16(26):3310-3317.
21. Powell-Tuck J, Hennessy E. A comparison of mid upper arm circumference, body mass index and weight loss as indices of undernutrition in acutely hospitalized patients. Clin Nutr 2003;22(3):307-312.
22. Shahar S, Hussain SS. Validation of Nutritional Screening Tools Against Anthropometric and Functional Assessments Among Elderly People in Selangor. Mal J Nutr 2007;13(1): 29-44.
23. Chapman KM, Ham JO, Pearlman RA. Longitudinal assessment of the nutritional status of elderly veterans. J Geront. 1996; 51:261-5.