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Original Article

The Association between Somatotype and Outcomes in Critically Ill Surgical Patients

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Abstract

Background: The somatotype is defined as the quantification of the present shape and composition of the human body. It can be simply categorized into 4 groups (Endomorphy, mesomorphy, ectomorphy and central group). Some studies show that mesomorphic component positively correlate to lean body mass which is acceptable proved that loss of lean body mass more than 25-30 % results in fatal outcomes in critically ill surgical patients. Because there is no study that prove the association between somatotype and outcomes in critically ill surgical patients. Therefore, the purpose of this study was to prove the association of the somatotype and the outcomes in critically ill surgical patients.

Patients and Methods: A total of 200 critically ill surgical patients in surgical intensive care unit at Maharaj Nakorn Chiang Mai hospital were collected. Demographic data and outcomes (28-day mortality rate, Hospital length of stay, ICU length of stay and duration of ventilator use) were compared among 4 groups of somatotypes (endomorphy, mesomorphy, ectomorphy and central group)

Results: There was no significant difference in outcomes of critically ill surgical patients between 4 groups of somatotypes (endomorphy, mesomorphy, ectomorphy and central group). The 28-day mortality rate are 0%, 16.7%, 14.9%, 8.6% ($p = 0.15$) in endomorphy, mesomorphy, ectomorphy and central group respectively. The median length of hospital stay was 15, 19, 31, 20 days ($p = 0.21$) respectively. The median length of ICU stay was 14, 7, 12, 8 days ($p = 0.36$) respectively. The median duration of ventilator use was 12, 5, 12, 7 days ($p = 0.38$) respectively.

Conclusion: This study shows that no significant difference in outcomes of critically ill surgical patients between 4 groups of somatotypes. 28-day mortality rate, length of hospital stay, length of ICU stays and duration of ventilator use.

Keywords: Somatotype, Endomorphy, Mesomorphy, Ectomorphy, Surgical intensive care unit

Introduction

The technique of somatotyping is used to appraise body shape and composition. The somatotype is defined as the quantification of the present shape and composition of the human body. It is expressed in a three-number rating representing endomorphy, mesomorphy and ectomorphy components respectively, always in the same order. Endomorphy is the relative fatness, mesomorphy is the relative musculoskeletal robustness, and ectomorphy is the relative linearity or slenderness of a physique. The Heath-Carter method of somatotyping is the most commonly used today and the anthropometric method has proven to be the most useful way to obtain somatotype[1].

Lean Body Mass is a component of body composition, calculated by subtracting body fat weight from total body weight[2]. Lean body mass is used in many literatures and proved that Lean body mass depletion results in

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increased length of hospital stay and loss of lean body mass more than 25-30% in critically ill surgical patients results in fatal outcomes[3,4].

Some studies showed that mesomorphic component in somatotype positively correlate with lean body mass[5-7]. However, there is no study that determine the association between somatotype and outcomes in critically ill surgical patients. Therefore, the purpose of this study was to determine the association between somatotype and ICU outcomes especially on the mortality.

Patients and Methods

This study was an ambispective cohort study. The data of 200 critically ill surgical patients in surgical intensive care unit of Department of Surgery, Faculty of Medicine, Chiang Mai University, Maharaj Nakorn Chiang Mai Hospital since 1 March 2012 to 31 March 2014 were collected. Some detail data were retrieved from THAI-SICU study research which collected the cases since 1 May 2012 to 31 October 2012[8]. We collected age, sex, diagnosis, body mass index (BMI), Acute physiologic and chronic health evaluation II (APACHE II) score, somatotype, length of hospital stays, length of ICU stays, duration of ventilator uses and 28-day mortality outcome. The Ethic committee of Faculty of Medicine, Chiang Mai University approved this study (SUR-2557-02120).

The Anthropometric Somatotype Method[1,9]

The anthropometric method of The Heath-Carter anthropometric somatotype (1990) was used in this study to obtain somatotype. Anthropometric equipment included a stadiometer or height scale and headboard, weighing scale, small sliding caliper, a flexible steel or fiberglass tape measure, and a skinfold caliper. Holtain Tanner/Whitehouse Skinfold caliper was used in this study (Figure 1).

Regarding the somatotype categorization, ten anthropometric dimensions are needed to calculate the anthropometric somatotype[1]: height, body weight, four skinfolds (triceps, subscapular, supra-spinale, medial calf), two bone breadths (bi-epicondylar humerus and femur), and two limb girths (arm flexed and tensed, calf). Regarding the skinfolds measurement, the measurer raises a fold of skin and subcutaneous tissue firmly between thumb and forefinger of the left hand and away from the underlying muscle at the marked site[1,9]. Apply the edge of the plates on the caliper branches 1 cm below the

Figure 1 Holtain Tanner/Whitehouse Skinfold Caliper

fingers of the left hand and allow them to exert their full pressure before reading the thickness of the fold[1,9]. The measurer took all skinfolds on the right side of the body. The subjects stand or sit on bed with relaxed position. The details of anthropometric dimension measurement were demonstrated in Table 1.

Ten anthropometric data were calculated and analyzed by software programmer named "Somatotype - calculation and analysis" which is a software product of Sweat technologies. This software can be legally downloaded from website "somatotype.org". It is expressed in a three-number rating representing endomorphy, mesomorphy and ectomorphy components respectively, always in the same order. Endomorphy is the relative fatness, mesomorphy is the relative musculoskeletal robustness, and ectomorphy is the relative linearity or slenderness of a physical appearance[1]. The details of calculation methods, rating method, equations for somatotype analysis, and 2-dimensions somatochart were detail on The Heath-Carter Anthropometric Somatotype-Manual (http://www.somatotype.org/Heath-CarterManual.pdf).

Somatotype could be simply categorized into 4 groups (endomorphy, mesomorphy, ectomorphy and central group).

1) Central: no component differs by more than one unit from the other two.

2) Endomorph: endomorphy is dominant, mesomorphy and ectomorphy are more than one-half unit lower.

3) Mesomorph: mesomorphy is dominant, endomorphy and ectomorphy are more than one-half unit lower.

4) Ectomorph: ectomorphy is dominant.

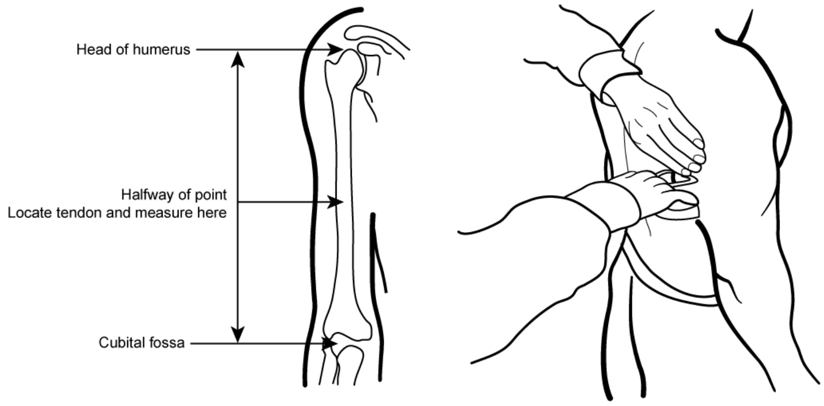

Figure 2 Triceps skinfold measurement (From Chittawatanarat K. Anthropometric measurement in clinical applications: height, body weight and body composition prediction [Clinical epidemiology]. Chiang Mai: Chiang Mai University; 2012: With Permission)

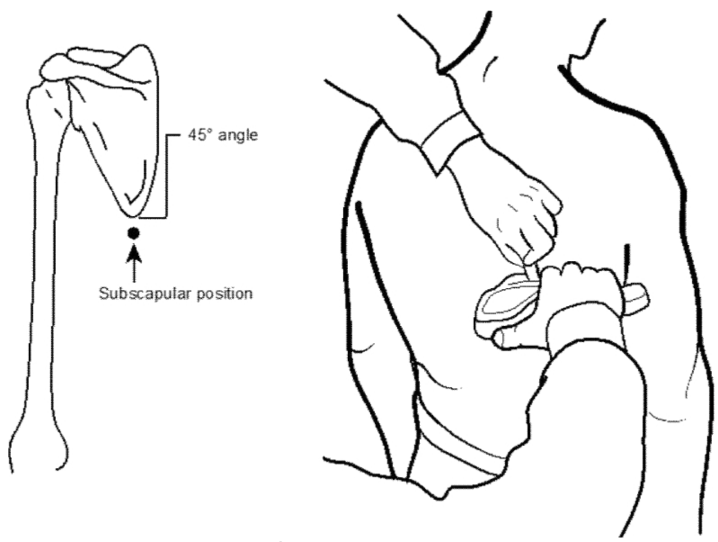

Figure 3 Subscapular skinfold measurement (From Chittawatanarat K. Anthropometric measurement in clinical applications: height, body weight and body composition prediction [Clinical epidemiology]. Chiang Mai: Chiang Mai University; 2012: With Permission)

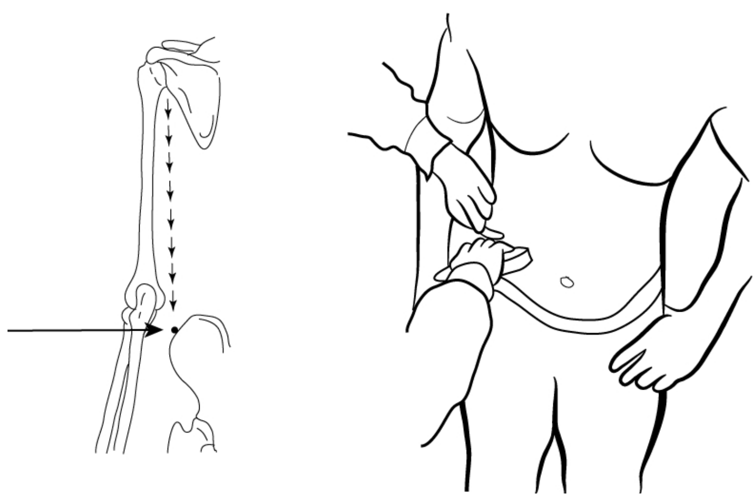

Figure 4 Supra-iliac skinfold measurement (From Chittawatanarat K. Anthropometric measurement in clinical applications: height, body weight and body composition prediction [Clinical epidemiology]. Chiang Mai: Chiang Mai University; 2012: With Permission)

Table 1 The ten anthropometric dimension for defining the patient somatotypes[1,9]

Parameters	Details of measurement
1. Stature (height)	Taken against a height scale or stadiometer. Take height with the subject standing straight, against an upright wall or stadiometer, touching the wall with heels, buttocks and back. Orient the head in the Frankfort plane (the upper border of the ear opening and the lower border of the eye socket on a horizontal line), and the heels together. Instruct the subject to stretch upward and to take and hold a full breath. Lower the headboard until it firmly touches the vertex. In case who cannot stand, the height is recorded from the identification card.
2. Body mass (weight):	The subject, wearing minimal clothing, stands in the center of the scale platform. Record weight to the nearest tenth of a kilogram. A correction is made for clothing so that nude weight is used in subsequent calculations
3. Triceps skinfold:	With the subject's arm hanging loosely in the anatomical position, raise a fold at the back of the arm at a level halfway on a line connecting the acromion and the olecranon processes. (Figure 2)
4. Subscapular skinfold	Raise the subscapular skinfold on a line from the inferior angle of the scapula in a direction that is obliquely downwards and laterally at 45 degrees. (Figure 3)
5. Supraspinale skinfold:	Raise the fold 5-7 cm (depending on the size of the subject) above the anterior superior iliac spine on a line to the anterior axillary border and on a diagonal line going downwards and medially at 45 degrees. (This skinfold was formerly called suprailiac, or anterior suprailiac. The name has been changed to distinguish it from other skinfolds called "suprailiac", but taken at different locations). (Figure 4)
6. Medial calf skinfold:	Raise a vertical skinfold on the medial side of the leg, at the level of the maximum girth of the calf.
7. Biepicondylar breadth of the humerus (right):	The width between the medial and lateral epicondyles of the humerus, with the shoulder and elbow flexed to 90 degrees. Apply the caliper at an angle approximately bisecting the angle of the elbow. Place firm pressure on the crossbars in order to compress the subcutaneous tissue.
8. Biepicondylar breadth of the femur (right):	Seat the subject with knee bent at a right angle. Measure the greatest distance between the lateral and medial epicondyles of the femur with firm pressure on the crossbars in order to compress the subcutaneous tissue.
9. Upper arm girth, elbow flexed and tensed (right):	The subject flexes the shoulder to 90 degrees and the elbow to 45 degrees, clenches the hand, and maximally contracts the elbow flexors and extensors. Take the measurement at the greatest girth of the arm.
10. Calf girth (right):	The subject stands with feet slightly apart. Place the tape around the calf and measure the maximum circumference

(Modified from The Heath-Carter Anthropometric Somatotype- Instruction Manual)

Statistical analysis

Statistical analysis was carried out using STATA software version 12.0. For categorical variables, differences were analyzed with the chi-square test. All continuous variables were compared using non-parametric Kruskal–Wallis one-way analysis of variance. Statistical significance was determined as *P* values of less than 0.05.

Results

Patient characteristics

Anthropometric data of 200 critically ill surgical patients were calculated and analyzed. Patients were simply categorized into each group of somatotypes (endomorphy, mesomorphy, ectomorphy and central group). four patients are in endomorph (Male 0, Female 4).24 patients are in mesomorph (Male 15, Female 9). 67 patients are in ectomorph (Male 44, Female 23).

96 patients are in central group (Male 67, Female 33). No significant difference in age (p = 0.16) and sex (p = 0.07). Average BMI in ectomorph is less than other groups (average BMI = 17.66 which is categorized in underweight) (p < 0.001). No significant difference in albumin and APACHE II score in each group. (p = 0.79 and 0.53 respectively) Patients characteristics are shown in Table 2.

Primary outcome

Primary outcome in this study is 28-day mortality rate. No significant difference was found in each group (p = 0.42).

The causes of death were sepsis and hemorrhage. However, no significant difference of causes of death was found among these groups (Table 3).

Secondary outcome

Secondary outcomes in this study are length of hospital stay, length of ICU stay and duration of ventilator use. No significant difference was found as shown in Table 3.

Table 2 Patients characteristic

	Endomorph (N=4)	**Mesomorph (N=24)**	**Ectomorph (N=67)**	**Central (N=105)**	***P*-value**
Median age (IQR)	75.5 (68.5-81)	68 (51-80.5)	69 (58-78)	63 (56-75)	0.160
Female (%)	4 (100.00)	9 (37.50)	23 (34.33)	38 (36.19)	0.070
Median BMI (IQR)	24.45 (23.58-6.16)	22.59 (20.77-3.96)	17.66 (16.61-8.69)	20.42 (19.84-20.90)	< 0.001
< 18.5(underweight)	0 (0.00)	0 (0.00)	49 (73.13)	7 (6.67)	< 0.001
18.5-22.9 (normal)	0 (0.00)	16 (66.67)	18 (26.87)	90 (85.71)	
23.0-24.9 (overweight)	3 (75.00)	5 (20.83)	0 (0.00)	6 (5.71)	
25-29.9 (obese I)	1 (25.00)	2 (8.33)	0 (0.00)	2 (1.90)	
≥ 30.0 (obese II)	0 (0.00)	1 (4.17)	0 (0.00)	0 (0.00)	
Median Albumin (IQR)	2.5 (2.05-2.95)	2.45 (2-2.9)	2.4 (1.8-2.9)	2.5 (2.1-2.9)	0.796
< 2.1	0 (0.00)	4 (16.67)	9 (13.43)	11 (10.48)	0.525
2.1-2.6	1 (25.00)	2 (8.33)	8 (11.94)	21 (20.00)	
2.7-3.4	2 (50.00)	11 (45.83)	23 (34.33)	46 (43.81)	
> 3.4	1 (25.00)	7 (29.17)	27 (40.30)	27 (25.71)	
Median APACHE II (IQR)	13 (8-18)	24 (9-28)	18 (10-24)	18 (12-24)	0.535

IQR: Interquartile range, BMI: Body mass index, APACHE II: Acute physiologic and chronic health evaluation II

Table 3 Primary and secondary outcome

	Endomorph (N=4)	Mesomorph (N=24)	Ectomorph (N=67)	Central (N=105)	*P*-value
Length of hospital stay	25 (13.5-36)	18.5 (8-36)	31 (16-53)	20 (11-34)	0.208
Length of ICU stay	14 (3.5-26.5)	6.5 (2-18)	12 (4-23)	8 (4-16)	0.362
Duration of ventilator	12 (2.5-24)	5 (1-18)	12 (3-21)	7 (3-15)	0.388
28-day mortality	0 (0.00)	4 (16.67)	10 (14.93)	9 (8.57)	0.422
Cause of death					
Sepsis	0 (0.00)	2 (8.33)	10 (14.92)	8 (7.62)	0.146
Hemorrhage	0 (0.00)	2 (8.33)	1 (1.49)	1 (0.95)	

Discussion

Currently, it is acceptable that loss of lean body mass more than 25-30% results in fatal outcomes in critically ill surgical patients[2]. Some studies showed positive correlation between mesomorphic component and lean body mass[6]. So, we expect that somatotype might relate to the outcomes in critically ill surgical patient. However, no previous study was designed to prove these associations as well as there was no evidence that somatotype may be used as a tool to predict the outcomes in these patients.

The Heath-Carter method of somatotyping is the most commonly used today to define present shape and body composition of human. This method has been used in many literatures of sport medicine to study the body shape and composition in various type of sport mans. There was no study in critically ill surgical patients yet. Ten anthropometric parameters in the Heath-Carter method of somatotype can be simply measured by general physician or nurse. It can easily be analyzed by software programmer that can be afforded from the official website “www.somatotype.org”.

The data from patient characteristics show that there is no significant difference in age, sex, albumin and APACHE II score. BMI in ectomorphy is significant less than other groups. So, we initially assume that ectomorphy may have less lean body mass and worse outcomes than other groups.

The results showed no significant difference on both primary outcome (28-day mortality rate) and secondary outcome (length of hospital stay, length of ICU stay, duration of ventilator use). Even though the results cannot show significant difference among these group, we notice that the length of hospital stay, length of ICU stay, duration of ventilator use and 28-day mortality rate are high in ectomorphy who have lower BMI than other groups. So, in our opinion, the study may need more sample size to make the significant difference.

Although this study was the bedside of measurement to determine the patient somatotype which might be extrapolated to the patient lean body mass or fat free mass. There were some inevitable limitations on this study:

1) we did not measure the concomitant body composition on these patients.

2) the limitation of rating form did not include some extreme value patients and the combination of somatotypes in one person.

3) Most of critically ill patient have been resuscitated before admission and there was edematous status at the first presentation. The measurement of skin fold in edematous patient was hardly to measure and error.

4) The distribution of each somatotypes is difference, most of patients were central (52.5%), the outcome difference might be not detected on the other group of somatotypes in this study.

In our opinion, Although the body composition tools are expensive, the direct measurement of body composition might lead to closely relation between the outcomes. Therefore, we suggest to use the body composition measurement method in the future of study.

Conclusion

This study shows that there is no significant difference in outcomes of critically ill surgical patients among 4 groups of somatotypes including 28-day mortality rate, length of hospital stay, length of ICU stays and duration of ventilator.

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บทคัดย่อ **ความสัมพันธ์ระหว่างรูปร่างและผลการรักษาในผู้ป่วยศัลยกรรม**

ธนากร ยิ่งรักพันธุ์ พ.บ., กวีศักดิ์ จิตตวัฒนรัตน์ พ.บ.

ภาควิชาศัลยศาสตร์ คณะแพทยศาสตร์ มหาวิทยาลัยเชียงใหม่

ความเป็นมา: รูปร่างสามารถประเมินได้จากการวัดและการดูสัดส่วนขององค์ประกอบของร่างกาย โดยทั่วไปมีการแบ่งเป็น 4 กลุ่ม (Endomorphy, mesomorphy, ectomorphy และ central) หลายการศึกษาพบว่า mesomorphy มีความสัมพันธ์กับมวลไร้ไขมัน ซึ่งเป็นที่ยอมรับกันโดยทั่วไปว่าการสูญเสียมวลไร้ไขมันมากกว่าร้อยละ 25 – 30 ส่งผลต่อการเพิ่มอัตราการเสียชีวิตในผู้ป่วยหนักศัลยกรรม เนื่องจากไม่เคยมีการศึกษาที่พิสูจน์ความสัมพันธ์ของรูปร่างกับผลการรักษาในผู้ป่วยหนักศัลยกรรม ดังนั้น การศึกษานี้จึงมีวัตถุประสงค์เพื่อพิสูจน์ความสัมพันธ์ระหว่างรูปร่างของผู้ป่วยกับผลการรักษาในผู้ป่วยหนักศัลยกรรม

ผู้ป่วยและวิธีการ: ผู้ป่วยจำนวน 200 คนในไอซียูศัลยกรรม โรงพยาบาลมหาราชนครเชียงใหม่ได้รับคัดเลือกเข้าการศึกษา บันทึกลักษณะของผู้ป่วยและผลการรักษา (การเสียชีวิตใน 28 วัน ระยะเวลานอนในโรงพยาบาล ระยะเวลานอนในไอซียู และระยะเวลาของการใช้เครื่องช่วยหายใจ) เปรียบเทียบในผู้ป่วยที่มีรูปร่างแตกต่างกัน 4 กลุ่ม (Endomorphy, mesomorphy, ectomorphy และ central)

ผลการศึกษา: ไม่พบความแตกต่างอย่างมีนัยสำคัญของผลการรักษาระหว่างรูปร่างต่างๆ ในผู้ป่วยศัลยกรรม โดยอัตราการเสียชีวิตที่ 28 วันตามลำดับ Endomorphy, mesomorphy, ectomorphy และ central คือร้อยละ 0, 16.7, 14.9 และ 8.6 ($p = 0.15$) ค่ามัธยฐานของการนอนโรงพยาบาลคือ 15, 19, 31 และ 20 วันตามลำดับ ($p = 0.21$) ค่ามัธยฐานของการนอนในไอซียู คือ 14, 7 ,12 และ 8 วันตามลำดับ ($p = 0.36$) ค่ามัธยฐานของการใช้เครื่องช่วยหายใจคือ 12, 5, 12 และ 7 วัน ตามลำดับ ($p = 0.38$)

สรุปผลการศึกษา: การศึกษานี้พบว่าไม่มีความแตกต่างระหว่างรูปร่างและผลการรักษาอย่างมีนัยสำคัญทางสถิติในผู้ป่วยหนักศัลยกรรมระหว่างรูปร่างทั้ง 4 กลุ่ม ได้แก่ อัตราการเสียชีวิตใน 28 วัน ระยะเวลาในการนอนโรงพยาบาล ระยะเวลานอนในไอซียู และระยะเวลาในการใช้เครื่องช่วยหายใจ