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Research article

Proposal of a score to detect the need for postoperative intensive care unit admission after bariatric surgery

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ABSTRACT

Background: We developed a multi-dimensional score which may help in predicting those patients, undergoing bariatric surgery, who may be in need for postoperative ICU admission and which may also help in avoiding unnecessary admission to the critical care units after bariatric surgery.
Methods: We collected the data of 111patients who underwent either laparoscopic gastric sleeve or bypass and studied the association between some risk factors related to obesity and their postoperative ICU admission. Those factors found to be statistically significant are included in the final score. The cutoff value of our scoring system is determined by running a Receiver Operating Curve (ROC) analysis.
Results: Forty patients (36%) were admitted to the ICU postoperatively. Our final score includes 7 independent variables; 6 found to be significantly related to post-bariatric surgery ICU admission; these are age, gender, BMI, ASA, obstructive sleep apnea and spirometry results, and the seventh is the history of venous thrombo-embolism. According to the ROC curve analysis, we set the score value of 10 as our cut-off value for the need of postoperative ICU admission. The score median value is 9. Males' odds to be admitted to the ICU after bariatric surgery are 11.9 times higher than females. Also, those with BMI above 50 kg m^{-2} have odds of 29.8 times higher than those below 50 kg m^{-2}.
Conclusions: We propose a scoring system for risk stratification, in which some of the well-known predictor risk factors are included in a simple way to help identify those high-risk patients undergoing bariatric surgery.
Conclusions: **Trial registry number:** NCT02976649.
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1. Introduction

Obesity is a current global threat, with an estimated 1.9 billion over weight adults, plus more than 600 million are suffering obesity [1]. Those with body mass index (BMI) of 30 kg m^{-2} or more constitute 27.7% of adult population in Egypt [2]. In parallel; there is an exponential increase of bariatric surgeries. Male sex, above 50 years, BMI more than 60 kg m^{-2}, cardiovascular disease, obstructive sleep apnoea syndrome, venous stasis, and intra-operative complications are known risk factors for intensive care unit (ICU) admission after bariatric surgery [3].

Nowadays, the prediction of ICU need post bariatric surgery depends on diverse protocols ranging from being BMI based to co-morbidities based overlooking in most the physiological reserve of such category of patients. However, despite the morbidity and mortality risks, most of patients admitted to ICU did not benefit from its services resulting in inefficient utilization [4].

The aim of this study is to create a multi-dimensional predictive score for the need of post-bariatric surgery ICU admission. First, to have an objective tool for assessment of our patients. Second, incorporating all the risk factors and physiological reserve in one comprehensive score. Third, easy tailoring of the predictive ICU needs of post bariatric surgeries with accumulated data and experiences.

2. Material and methods

This is an observational retrospective study which was approved by the Ain Shams University, Faculty of Medicine Research Ethics Committee (*Ref: FMASU R 19/2016*) and registered with Clinical trials.gov (*ref: NCT02976649*). The requirement for written informed consent was waived by the ethics committee.

The first step in our work was to develop a preliminary score. This score includes independent factors we considered as risk fac-

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tors for the need for postoperative ICU admission after bariatric surgery. We applied this score on pilot group of patients; first to find those factors which are significantly related to the need for post-bariatric surgery ICU admission, so that to be included in the final score and second to determine the cutoff score value for the prediction of our dependent factor; the need for ICU admission. We collected the data of 111 patients who have been operated upon for either laparoscopic gastric sleeve or laparoscopic gastric bypass during the period from January to June 2016. All the surgeries were performed in Ain Shams University hospitals during the previously mentioned period. The data were collected from the database registry of the general surgery department in our University Hospital. Patients were indicated for surgery if their body mass index (BMI) $\geq$35 kg m^{-2} with obesity-related co-morbidities or $\geq$40 kg m^{-2} with or without co-morbidities [5]. Patients were excluded in case of postoperative surgical complications, conversion to open surgery or in case of redo. Unfortunately, the available postoperative data for those admitted to the ICU were only about the duration of mechanical ventilation and the duration of their ICU stay.

The items included in the preliminary score are age, gender, BMI, physical status of the patient according to the American Society of Anaesthesiologist (ASA) classification [6], the presence of obstructive sleep apnoea (OSA). Also, we included the spirometry results as an indicator of pulmonary function, history of venous thrombo-embolic events (VTE), and finally type and duration of surgery. All these data besides the admission to the ICU postoperatively were collected for each patient. The association between each of these items and the admission to ICU postoperatively were examined using Chi-square or Fischer exact test as appropriate. For this univariate analysis, the patients were divided into 2 age groups; below 40 and 40 years old or above. Also, the independent variable BMI was examined by dividing the patients into 2 groups; those with BMI below 50 kg m^{-2} or 50 kg m^{-2} and above.

According to the spirometry results, patients are divided into two groups as either normal or with obstructive or restrictive lung disease.

Also, for the univariate analysis, the patients are classified as ASA II or above II and again as with or without obstructive sleep apnoea.

The diagnosis of co-morbid conditions followed standard recommendations. As an example, Diabetes mellitus required an elevated fasting blood sugar of $\geq$120 mg/dl on two or more tests on different days and the recommendation of a diabetic diet by the primary care physician, oral hypoglycaemic medications or insulin. Hypertension required sitting repeated blood pressure measurements of $\geq$150 mmHg systolic and/or $\geq$90 mmHg diastolic or the use of antihypertensive medications. Obstructive Sleep Apnoea required polysomnographic findings demonstrating a respiratory disturbance index $\geq$10 hypopnoeic or apnoeic episodes/hour of sleep.

Per the results of the univariate analysis, only the items with significant association with our dependent factor, the postoperative ICU admission, will be included in the final score.

Finally, we obtained a score sheet of 7 elements found to be significantly related to the need for postoperative ICU admission: Age, Gender, BMI, American society of anaesthesiologist physical status, obstructive sleep apnoea, spirometry results and history of venous thrombo-embolism.

In our final score sheet, age and BMI were further divided into 4 sub groups. Each element will be given a score from 1 to 4 except the gender category which has only 2 possible outcomes will be given a score of either 1 or 2. Male gender was given a higher score because of the known comorbidities related to the android type of obesity. Also, per the ASA classification [6], none of our patients belongs to ASA I physical status (all have BMI above 30) so we started our score sheet with ASA II patients who will be given a score of 1 and so on. The results of the spirometry; either normal, mild, moderate or severe obstructive or restrictive are given scores from 1 to 4 respectively. The pulmonary functions were evaluated by following the American Thoracic Society (ATS) grades for diagnosing the pattern and quantifying the severity of the defect [7].

The presence of OSA and the degree of venous thrombo-embolic disease will be scored as shown in Table 3.

Thus, the score value of any patient will range from 7 to 25. The sum of all elements was calculated for each patient.

We run a Receiver Operating Characteristic (ROC) curve analysis to determine the score cutoff value that best discriminates between patients who will be in need for postoperative ICU admission and those who will not. This will be the value with the best combination between sensitivity and false positive rate.

Finally, we conducted a binomial logistic regression to ascertain the effects of gender, age, BMI, presence of OSA and results of the spirometry on the likelihood that patients will need post-bariatric surgery ICU admission.

2.1. Statistical analysis

Data were analysed using Statistical Package for Social Science (SPSS) version 21.0. Chicago, Illinois, USA. Quantitative data were expressed as mean ± standard deviation (SD) or median (range) Qualitative data were expressed as frequency and percentage. Chi-square (X2) and Fischer exact tests were used to compare proportions between two qualitative parameters. P-value < 0.05 was considered significant and P-value < 0.001 was considered highly significant. Receiver Operating Characteristic (ROC) curve was used to evaluate our score and to determine the cut off score value that best discriminates between patients who will need postoperative ICU admission and those who do not. Sample size was determined based on a range of ICU admission after bariatric surgery from 5 to 24% with α error of 0.05 and power of the study 80%.

3. Results

The demographic characteristics of the patients are represented in Table 1; males represent 17.1% of the patients. The highest BMI was 74 while the lowest was 35. Forty patients were admitted to the ICU postoperatively representing about 36% of patients. Of these admitted patients, 31 were admitted because of BMI above 50 with or without abnormal spirometry, the remaining nine were admitted because of abnormal spirometry results or their complaint of OSA or combination of both. Those nine patients who needed mechanical ventilation were weaned in the same day of admission to the ICU. All the patients were discharged the next morning except those who needed mechanical ventilation were discharged after 48 hours. No CPAP masks were applied because of its possible hazardous effect on the anastomosis.

Table 1
Demographic characteristics of the patients and surgeries. OSA, obstructive sleep apnoea; ASA, American society of anaesthesiologists; VTE, venous thromboembolism.

Age (years)	33.44 ± 9.2[a]
Male gender	19 (17.1)[b]
BMI (kg m^{-2})	48.78 ± 8.2[a]
Patients with OSA	26 (23.4)[b]
ASA physical status III or IV	43 (38.7)[b]
Patients with abnormal spirometry results	41 (36.9)[b]
Patients with history of VTE	4 (3.6)[b]
Type of surgery (Gastric Bypass)	39 (35.1)[b]
Duration of surgery (hours)	2.2 ± 0.66[a]
ICU admission (yes)	40 (36)[b]
Postoperative ventilation (yes)	9 (8.1)[b]

[a] Data presented as mean±SD.
[b] Data presented as count (percentage).

Table 2
The results of the univariate analysis of the different independent variables in relation to the need for ICU admission. BMI, body mass index; OSA, obstructive sleep apnoea; ASA, American society of anaesthesiologists. Values are count(percentage).

Category	Number admitted to the ICU (percentage within the same category)	*P*-value
Age ≥ 40 years	18 (69.2)	0.000056[a]
BMI ≥ 50 kg m^{-2}	31 (79.5)	<0.0001[a]
Male gender	14 (73.7)	0.000174[a]
Patients with OSA	15 (57.7)	0.009[a]
ASA III and IV	28 (65.11)	0.000019[a]
Patients with abnormal spirometry results	21 (51.2)	0.045[b]
Gastric Bypass surgery	18 (46.2)	0.102[a]
Duration of surgery > 2 hours	20 (38.4)	0.08[a]

[a] Chi-square test.
[b] Fischer Exact test.

The results of the univariate analysis are shown in Table 2. The independent variables found to be significantly related to post-bariatric surgery ICU admission are those with p value < 0.05 and constitute the main items of our final score (Table 3) in addition to one more item which is the history of VTE which was not included in the univariate or multivariate analysis because of the very small number of patients (4 patients) with history of VTE, but since it is a well-known and a common risk factor in morbidly obese patients, we thought it must be included as an item in our final score.

The score median value was 9 with a range of 7–18 as shown in Fig. 1.

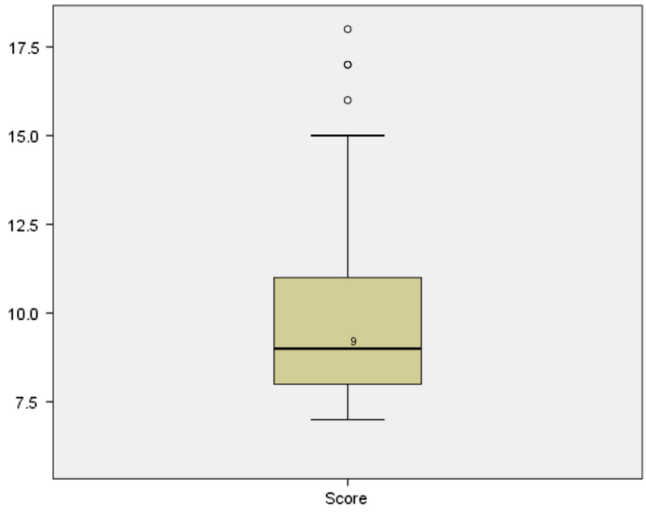
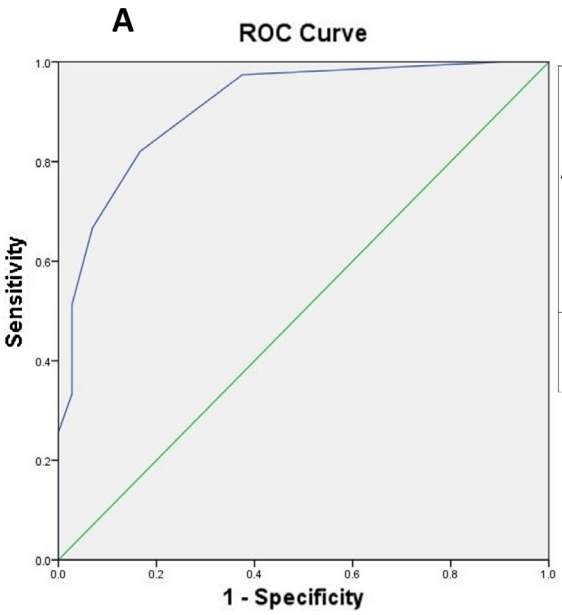


Fig. 1. A boxplot of the median score value obtained and the range.

Table 3
The final score sheet. F, female; M, male; BMI, body mass index; ASA, American society of anesthesiologists; CPAP, continuous positive airway pressure; VTE, venous thromboembolism; DVT, deep venous thrombosis.

	1	2	3	4	Score
Age (years)	20 : <40	40 : <50	50 : <60	≥60 years	4
Gender	F	M			2
BMI ($kg.m^{-2}$)	< 40	40 : <50	50 : <60	≥60	4
ASA physical status	II	III	≥ IV		3
Obstructive Sleep Apnoea	No		yes, but no CPAP	need for CPAP	4
Spirometry	normal	mild	moderate	severe	4
History of VTE	no	Venous ulcer	DVT	Pulmonary embolism	4
Total score					25



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Area Under the Curve	Std. Error	Asymptotic Sig.	95% Confidence Interval	
			Lower Bound	Upper Bound
0.910	0.028	0.0001	0.856	0.965

Fig. 2. ROC curve displaying the score true positive rate (sensitivity) as a function of its false positive rate (1 minus specificity).

Table 4
Odds ratio of the different risk factors and their confidence intervals. BMI, body mass index; OSA, obstructive sleep apnoea.

Independent variable		Odds ratio	95% Confidence Interval	
			Lower	Upper
Male Gender		11.932	2.174	65.488
BMI $\geq$ 50 kg m^{-2}		29.818	7.024	126.580
Age $\geq$ 40 years		16.594	2.953	93.237
History of OSA		1.778	1.151	4.017
Spirometry results	Mild	2.740	0.391	19.205
	Moderate	3.119	0.660	14.742
	Severe	4.871	0.880	26.962

Visual inspection of the ROC curve shows that a score value of 9.5 has the optimal combination of sensitivity and false positive (1-specificity) rate, Fig. 2 represents the ROC curve. Accordingly, we set the score value of 10 as our cut-off score value for the need of postoperative ICU admission. The area under the curve (AUC) and its statistical analysis are also given in Fig. 2. This figure displays information about the overall diagnostic value of our score. The (AUC) is 0.91 which means that when deciding which of two randomly paired patients will be in need for ICU admission post bariatric surgery, we would choose correctly 91% of the time if we select the patient with the higher score value. The highly significant p value indicates that our score discriminates between a patient who will need ICU admission and another who will not much better than a chance.

The independent variables included in the logistic regression analysis are; age $\geq$ 40 years, BMI $\geq$ 50 kg m^{-2}, male gender, the presence of OSA and the results of the spirometry. We didn't include the history of thrombo-venous embolism because of the very small number of patients in the sample with a history of VTE as mentioned before.

Males' odds to be admitted to the ICU after bariatric surgery are 11.9 times higher than females. Also, those with BMI above 50 kg m^{-2} have odds of 29.8 times higher than those below 50 kg m^{-2}.

The odds of patients with severe restrictive or obstructive lung disease to be admitted to the ICU are 4.87 higher than those with normal spirometry results. Odds ratios and their confidence intervals are given in Table 4.

4. Discussion

Bariatric surgeries have been shown to be superior over medical treatment or lifestyle modifications in treating morbid obesity. This type of surgery provides more sustained and stable weight loss [8]. The popularity of bariatric surgeries in Egypt now, as a method of treating morbid obesity, is increasing widely. Morbid obesity is associated with multiple risk factors which may necessitate the need for ICU admission postoperatively. However, because not all patients undergoing bariatric surgeries will be in need for ICU admission and because of the low resources, there was a need to preoperatively identify and predict those patients who will be in need to be followed up in a critical care unit. The body mass index was used solely before to classify patients for whom an ICU bed will be reserved for postoperative follow up. However, we realised that other risk factors should be taken in consideration. The results of the univariate and multivariate analysis identify some risk factors for postoperative ICU admission. Male gender, super obesity (BMI $\geq$ 50 kg m^{-2}) and age above 40 years have the highest odds ratio to be admitted to ICU after bariatric surgery. Many studies have established these three variables as risk factors for mortality and morbidity after bariatric surgery. Also, other studies found that these risk factors are also related to surgical complications. Poulouse and colleagues [9], suggested that the identification of risk factors for adverse events after bariatric surgery could help to identify high risk groups and improve patient safety. They found that male gender was predictive of both respiratory failure as well as surgical complications as accidental puncture and laceration. They

also found that advanced age was a strong risk factor for surgical complications, pulmonary embolism or DVT and respiratory failure.

Other studies reported that patients with greater preoperative body weight and hypertension, and those with high risk of pulmonary embolism, demonstrated a greater risk of mortality after bariatric surgery [10].

Also, male patients with greater BMI were shown to have a greater risk for severe life-threatening complications and advanced age was a predictive of greater mortality after gastric bypass surgery [11,12].

Livingstone and colleagues [12] analysed risk factors and their relationship to surgical outcomes after bariatric surgery and identified ten independent factors as predictors of complications. Of these, the 4 most influential factors for predicting a complication after bariatric surgery were male gender, revision surgery, increasing age and increasing weight.

After establishing our final score, we run the ROC analysis to evaluate the accuracy of our score which depends on how well the score separates the group being tested into those who need and those who don't need postoperative ICU admission. Accuracy is measured by the area under the ROC curve. An area of 1 represents a perfect test; an area of 0.5 represents a worthless test. Our p value indicates that our area under the curve is not equal to 0.5.

Open and redo bariatric surgeries are usually associated with more complicated postoperative course. We excluded these types of bariatric surgeries in our study as patients undergoing open or redo bariatric procedures are usually admitted to ICU postoperatively. Morgan and colleagues [4] showed in a population-based multicentre study that a 4.9% out of 12062 patients undergoing bariatric surgeries required ICU admission postoperatively either planned or unplanned and such patients tend to be of male gender, older age, have DM and have undergone open or redo bariatric surgeries.

Regarding patient safety in bariatric surgery, many scoring systems have been proposed to predict risk factors related to morbidity and mortality after bariatric surgery. DeMaria and colleagues [13] proposed a score system to predict mortality risk in patients undergoing gastric bypass surgery. They found four independent risk factors related to mortality in these patients. Male gender, BMI $\geq 50\ kg\ m^{-2}$, hypertension and pulmonary embolus risk. They added age as a fifth variable because it was significant in other studies. In our ultimate score, we also added the history of thrombo-embolic disease because of its significance in other studies. The validity of De Maria and colleagues' score had been verified for validity by many other researchers [14].

We think that the limitations of this study appear in the relatively small number of patients included in this study compared to other similar researches. This was due to the newly developed patient data registry system in our hospital. Also, other risk factors which, we think, might be included such as the surgeon' s experience, the obesity hypoventilation syndrome because the data of which were not available.

5. Conclusion

In this study, we propose a basic scoring system for risk stratification, in which some of the well-known predictor risk factors are included in a simple way to help identify those high-risk patients undergoing bariatric surgery. Future studies, we think, must focus on validation of this score on a wider range of patients with different characteristics and on different settings to provide a more comprehensive scoring system which may help physicians to better clarify the expected risks to their patients and to choose the best treatment option.

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Conflict of interest

No conflict of interest declared.

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