International Journal of Research Studies in Medical and Health Sciences
Volume 2, Issue 11, 2017, PP 21-28
ISSN : 2456-6373

Postoperative Intensive Care Surveillance A Tool to Optimize ICU-Beds Management?

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ABSTRACT

Background: *Several score systems were created to stratify perioperative risk and predict mortality. Our study rises from the needing of a rapid and simple system to identify the patient worthy of Postoperative Intensive Surveillance (PoIS).*

Methods: *In the first phase we retrospectively investigated on patients underwent to elective surgery searching for determining factors (DFs) for postoperative ICU admission. Later, we prospectively studied how DFs could predict the admission in ICU of consecutive patients scheduled for elective surgery during a three-months period and we create an index, named PoIS (Post-operative Intensive Surveillance), based on the results of this analysis. We used surgical invasiveness (SI), Diabetes Mellitus (DM), Cardiomyopathy (CMP), Cerebrovascular Disease (CVD), Body Mass Index (BMI), age, serum creatinine level (sCr), Forced Expiratory Volume 1s/Forced Vital Capacity ratio (FEV1/FVC) and male sex for the development of the original model. We classified SI from G1 (lowest) to G5 (highest). Finally, only items statistically significant for PoIS were prospectively tested in the next step. ASA and %Morbidity-POSSUM values were recorded as comparative scores, too.*

Results: *Multivariate analysis showed that G2, G3, G4, DM, CMP and male-sex were significant for the judgement of PoIS. PoIS-score and %Morbidity-POSSUM showed similar predictive values: AUC were 0.837 and 0.840, respectively. Conversely, AUC of ASA-score was 0.733.*

Conclusions: *Our results show that the power of prediction of postoperative morbidity of PoIS and POSSUM resulted coincident and better than ASA score. We searched for a new score to optimize ICU-admission management and our results may be promising.*

Keywords: *Critical care-Humans-Postoperative period.*

INTRODUCTION

Prediction of postoperative intensive care unit (ICU) admission is performed routinely worldwide. Identifying the patients who are most likely to need intensive care is crucial. Since decision to admit to the ICU varies across institutions, well-defined criteria for postoperative patients need to prevent under- and overuse of ICU. In the era of scarcity of ICU beds unnecessary admission of low-risk patients may delay ICU care for truly high-risk patients contributing to their poor outcome.

Several scoring systems have been developed to determine perioperative risk, [1-3]. The American Society of Anesthesiologists (ASA) and the Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity (POSSUM) are two of the most widely used scoring systems for surgical patients, [4,5]. Nevertheless they have several limitations. ASA is a 6-category physical status classification system; its main disadvantage is subjectivity and it does not include variables specific to surgical invasiveness. More complex POSSUM evaluates two components: a physiological score including 12 factors and a surgical severity score with 6 operative factors. It was developed primarily for prediction of mortality and surgical units' performance. Its original version included Morbidity risk prediction too, [6]. Over-prediction of mortality had been its most criticized aspect, [7,8].

Despite we are aware that ICU admission may be often subjective and/or related to an Institutional policy, our study rises from the needing of a rapid and simple system to identify, at our best, patients worthy of postoperative intensive surveillance in order to ameliorate the policy of our hospital about the management of limited resources as ICU-beds are.

METHODS

The study was approved by the Ethical Committee of Humanitas Clinical and Research Centre and Humanitas University, Rozzano (Milan), Italy (approval number: 08/16); phone +390282247216; email: comitato.etico@humanitas.it. Trial was registered on clinicaltrials.gov (NCT02894788).

We performed the study in three phases as showed in Figure 1. The first step (ST1) was a retrospective investigation of institutional surgical database of one year of scheduled elective surgery (October 2011-November 2012). Authors reviewed all preoperative evaluation form (PEF) searching for any risk factors for postoperative ICU admission that we named determining factors (DFs) and recorded into a database for statistical analysis. Considered DFs were: age, sex, Body Mass Index (BMI), Diabetes Mellitus (DM), any Cardiomyopathy (CMP), Cerebrovascular Disease (CVD), serum creatinine level (sCr), Forced Expiratory Volume 1s/Forced Vital Capacity ratio (FEV1/FVC) and surgical invasiveness (SI). In this database patients were classified only according ASA score. Furthermore, one of the authors re-evaluated the preoperative exams and re-assigned an ASA score to patients in a blinded way (he did not know the ASA score recorded into the database), aiming to measure how many times it would be different from the preoperative evaluation. The statistical analysis considered only the official preoperative ASA score assignation reported on PEF. Usually in this situation, what is required is a third abstractor to resolve any conflicts between the two other raters, but the reliability of ASA score was not the aim of our trial.

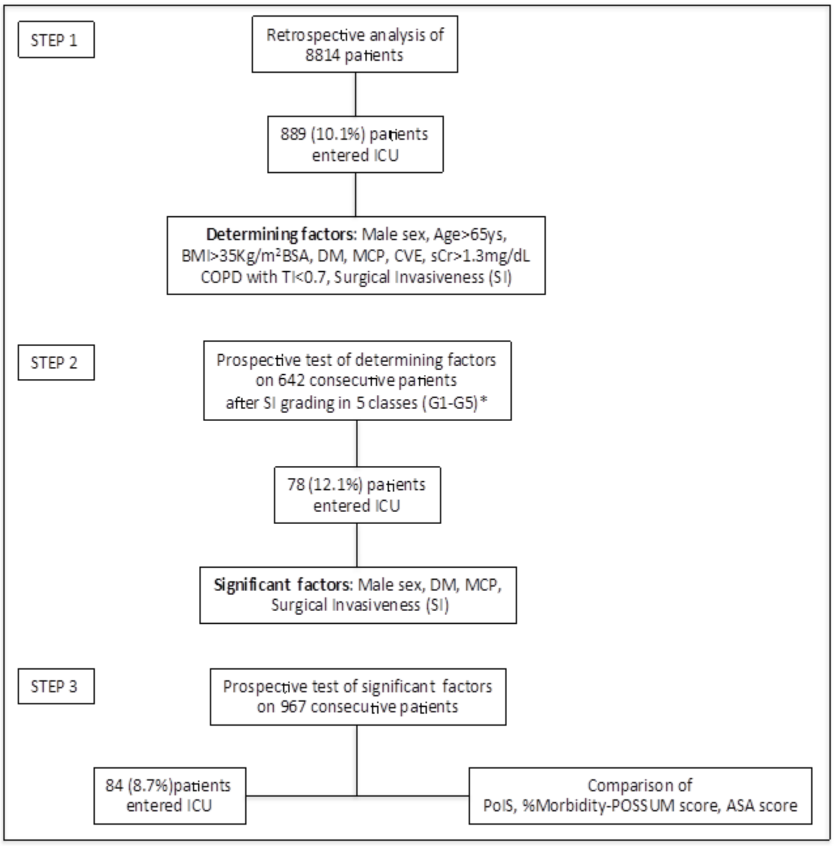

Figure1. *The flow chart of the study*

ICU=Intensive Care Unit; BMI=Body Mass Index; BSA=Body Surface Area; DM=Diabetes Mellitus; MCP=Myocardiopathy; CVE=Cerebrovascular Events; sCr=Serum Creatinine; COPD=Chronic Obstructive Pulmonary Disease; TI=Tiffenau Index.

**G5 class were excluded as patients who underwent such a surgery entered ICU by default.*

Since we consider that surgical invasiveness (SI), that means the complexity, the anatomic demolition and the lasting of the operation, is a no-neglectable factor, we divided operations that are routinely performed in our hospital in five classes according the invasiveness. We graded surgery from G1 (operation with the lowest invasiveness) to G5 (operation with the highest invasiveness), (Figure 2). The surgical-grading definition was collectively discussed and approved in our Department basing on the surgical classification reported into the section "Preoperative tests for elective surgery" of the NHS website, [2]. Patients who undergo G5 operations are routinely admitted to ICU by default. Consequently, G5 subjects were excluded from the study.

G1	G2	G3	G4	G5
Appendectomy (no peritonitis)	Abdominoplasty	No aortic open vascular surger	Pancreaticoduodenectomy	Thoracic aorta open surgery
Arthroscopy	Open surgery of nephrolithiasis	Distal pancreatic resection	Abdominal aorta open surgery	Neck surgery with flap reconstruction
Superficial biopsy	Spine surgery	Biliay duct surgery	Spine cord surgery	Brain open surgery
Hand surgery	Peripheral minor vascular surgery (Fogarty)	EVAR and TEVAR	Disarticulation/Hemipelvectomy/Extended amputation	Peritonectomy/HIPEC
Dermatologic-plastic surgery	Intestinal recanalization	Radical bladder resection	Oesophagectomy	Extended hepatic resection
Eye surgery	Thyroglossal duct cysts excision	Abdominal debulking	Pleurectomy	Vertebrectomy
Vascular surgery of upper limbs	Cholecystectomy	Elective cerebral aneurysm embolization	Pneumonectomy	Cardiac surgery
Colonscopy	Cryoablation of cancer	Pleural neoplasm resection	Hepatic resection	
Uterine conization	Infected hematoma drainage of limbs	Thymectomy		
Vocal cordectomy	Partial thyroidectomy	Spinal cord neoplasm resection		
Hemorrhoidectomy	Rigid bronchoscopy for airways stenting/laser therapy	Deep/Complex oro-pharyngeal neoplasm surgery		
Foramen ovale closure	Renal tumor enucleoresection	Surgery for pheocromocytoma		
Diverticulo of Zenker resection	Surgery for endometriosis	Gastrectomy		
Hematoma drainage of limbs (no infection)	Ear surgery	Hysterectomy-ovarectomy (open/robot)		
Circumcision	Surgical excision of superficial oro-pharyngeal tumor	Pulmonary lobectomy (also VATS)		
ERCP	Nasal surgery for neoplasm	Trans-nasal neurosurgery		
Abdominal hernia repair	Surgery of neoplasm of limbs	Nephrectomy		
Dermatological surgery by local anesthesia	Ilizarov placement	RALP		
No prothetic shoulder surgery	Incisional hernia repair	Retroperitoneal neoplasm resection		
Mediastinoscopy	Video-assisted abdominal exploration/biopsy	Intestinal resection		
Neprhostomy	Bilateral mastectomy(+/- prothesis)	Femur fracture repair/hip prosthesis		
Pyeloureteral junction plastic procedure	Uterine myomectomy	Carotid endarterectomy		
ICSI	NISSEN-HELLER DOR	Radica thyroidectomy		
Gastrointestinal endoscopic procedures	NUSS-Ravitch	Diaphragmatic hernia repair		
Uterine curettage	Surgical treatment of fractured long bones (not femur)			
Breast cancer resection and similar	Parathyroidectomy			
Cruciate ligament repair	Parotidectomy			
NUSS-bars replacement	Millin's prostatectomy			
FESS and similar	Shoulder-knee prosthesis placement			
RIRS-URS-PCNL	Rib resection			
Lower limbs venous surgery	Ovarian cyst resection and similar			
Surgical repair of fractured little bones	Video-assisted thoracic sympathectomy (vats)			
Surgery for bladder control (sling)	Splenectomy			
Stapedotomy	Neck dissection			
Ureteral stenting	VATS for biopsy/pleurodesis			
Achilles tendon repair	Pulmonary wedge resection/segmentectomy			
Tympanoplasty	Prothetic shoulder surgery			
TIPS	False joint repair			
TURBT-TURP-Uretrotomy and similar				
External genital surgery				
Ilizarov replacement				

Figure2. *Surgical invasiveness grading*

In the second step (ST2), we prospectively studied how DFs worked on consecutive patients scheduled for elective surgery during a three-months period (March 2014-May 2014). Particularly we investigated how these factors could predict the admission in ICU after surgery, in a blinded way (the anesthesiologist did the preoperative evaluation without knowing that the Authors would have recorded the evaluation data reported during the preoperative anesthesiological consultation). Then we created an index, named PoIS (Post-operative Intensive Surveillance), based on the results of the multivariate analysis. We used surgical grading (G1, G2, G3, G4), history of Diabetes Mellitus (DM), any Cardiomyopathy (CMP), Cerebrovascular Disease (CVD, including Transient Ischemic Attack, TIA, and Stroke with or without neurologic deficit), Body Mass Index (BMI), age, serum creatinine level (sCr), FEV_1/FVC ratio (i.e. Tiffenau Index, TI) and male sex for the development of the original model. Despite FEV_1/FVC ratio was lacking in many cases, it was inserted into the original score because, when patient underwent Pulmonary Function Test (PFT) it was a determining factor over the decision-making pathway about post-operative ICU admittance.

Then, basing on the items that resulted significant for PoIS among the above mentioned data, we created a nomogram of Harrell to simply show how much each item could predict postoperative ICU needing. Finally, the nomogram of Harrell was converted into a Microsoft Excel file to compute the score (PoIS-score) and test it in the next step.

The third step (ST3) consisted of the prospective evaluation of PoIS-score on consecutive patients scheduled for elective surgery (G1-G4) between March 2015 and August 2015. Patients who underwent more than one surgical procedure (G1+G3, for instance) were excluded. Furthermore, we excluded cases when planned procedure was not the performed operation which the patient was submitted to. ASA and %

Morbidity-POSSUM values were recorded as comparative scores, too.

Statistics

Data were expressed as number and percentage or mean and standard deviation or median and range, when appropriate. A binary logistic regression model was developed with some predictor items of postoperative ICU. Predictors included in the model were selected based on results of the univariate analysis. All variables with a p<0.2 were included in the multivariate model. We assumed p<0.05 for statistical significance. Analysis was performed by Stata 13 Software (StataCorp, 4905 Lakeway Drive – College Station, Texas 77845-4512 USA).

Results

At the first step (ST1) of the study out of 8814 patients scheduled for elective surgery, 889 (10.1%) were admitted in our ICU postoperatively.

We found that ASA score >1 assigned to patients by the anesthesiologist at the preoperative visit emanated from the following factors: age > 65 years, BMI > 35 kg/m^2 of body surface area, DM, ischemic, valvular or dilated CMP, CVD, sCr > 2 mg/dL, chronic obstructive pulmonary disease (COPD) with FEV1/FVC ratio < 0.7, and ranged from ASA 1 to ASA 4.

Out of the 889 patients admitted to ICU, 32 (3.6%) were G1 grade of surgery, 76 (8.6%) were G2, 122 were G3 (13.7%) and the majority were G4 (659, 74.2%). During preoperative evaluation was assigned ASA 1 in 141 (15.9%), ASA 2 in 420 (47.3%), ASA 3 in 420 (47.3%) and ASA 4 in 30 (3.4%) patients. About the re-assignation of ASA score we found it did not match the preoperative value in 340 cases (38.2%). Out of them 338 regarding the ASA 2 - ASA 3 assignment, 1 patient scored ASA 2 preoperatively was re-evaluated ASA 1 and one ASA 4 patient was re-evaluated ASA 3. Patients assigned to ASA 2 and ASA 3 class were the majority of the sample (47.3% and 33.5%, respectively) who entered ICU postoperatively.

ST2 analysis showed that 69 patients (10.8%) out of 642 were admitted to our ICU, postoperatively. Only 3 (1.4%) G1 patients entered ICU postoperatively. Compared to G1-patients without risk factors, G2-G3-G4 showed, at the univariate analysis, an increased Odds Ratio for postoperative ICU. Almost all the considered variables were statistically significant at univariate analysis, but at the multivariate analysis only G2 [OR 4.98 (1.19 - 20.77), p=0.028], G3 [OR 13.00 (3.63 - 46.51), p<0.001], G4 [OR 60.22 (16.39 - 221.2), p<0.001], diabetes mellitus [OR 3.16 (1.51 - 6.61), p=0,002], cardiomyopathy [OR 13.51 (5.25 - 34.78), p<0.001], and male gender [OR 2.48 (1.27 – 4.82), p=0.007] were confirmed (Table 1), and were included in the PoIS scoring system. FEV_1/FVC ratio and CVE were excluded. Nomogram of Harrell (Figure 3) showed the weight of each items in determining postoperative surveillance needing. The predictive value of G2, G3 and G4 were computed in comparison with G1 that showed the lowest-risk for postoperative ICU admission.

Table1. *Univariate and Multivariate analysis*

Univariateanalysis				Multivariate analysis			
Items	**Odds Ratio**	**p**	**Conf. Interv.95%**	**Items**	**Odds Ratio**	**p**	**Conf. 95% Interv.**
G2	4.57	0.038	1.09-19.12	**G2**	4.43	0.043	1.04-18.79
G3	11.62	0.000	3.24-41.69	**G3**	10.69	0.000	2.97-38.51
G4	59.94	0.000	16.37-219.40	**G4**	62.38	0.000	16.99-229.00
DM	3.09	0.003	1.47-6.49	**DM**	3.04	0.003	1.44-6.41
MCP	13.1	0.000	5.04-34.0	**MCP**	13.97	0.000	5.36-36.36
CVD	2.57	0.042	1.03-6.41	**CVD**	2.46	0.057	0.97-6.24
Male	2.46	0.012	1.25-4.68	**Male**	2.39	0.012	1.21-4.69

In the prospective step (ST3) 967 patients were collected. During the preoperative evaluation in 183 (18.9%) cases postoperative ICU admittance was considered appropriate by the anesthesiologist. Sixty-one of them (33.3%) really entered intensive care unit. Conversely, ICU was not preoperatively predicted for 784 (81.1%) subjects, but 23 (2.9%) required it after surgery. Then, eighty-four (8.7%) entered our ICU postoperatively and 883 (91.3%) did not. Table 2 reports the results of the prospective test of the score according three classes of PoIS score we named low risk (PoIS-score <0.10), intermediate risk (PoIS score 0.10-0.25) and high risk (PoIS score >0.25) for post-operative ICU appropriateness. Among ICU-admitted patients, 8 (1.6%) were within the low-risk class (PoIS score <0.10) which included 512 subjects, 18 (6.9%) belonged to the intermediate-risk class (PoIS score 0.10-0.25) including 261 subjects and 58 (29.9%) to the high-risk class (PoIS score >0.25) including 194 patients, (Figure 4).

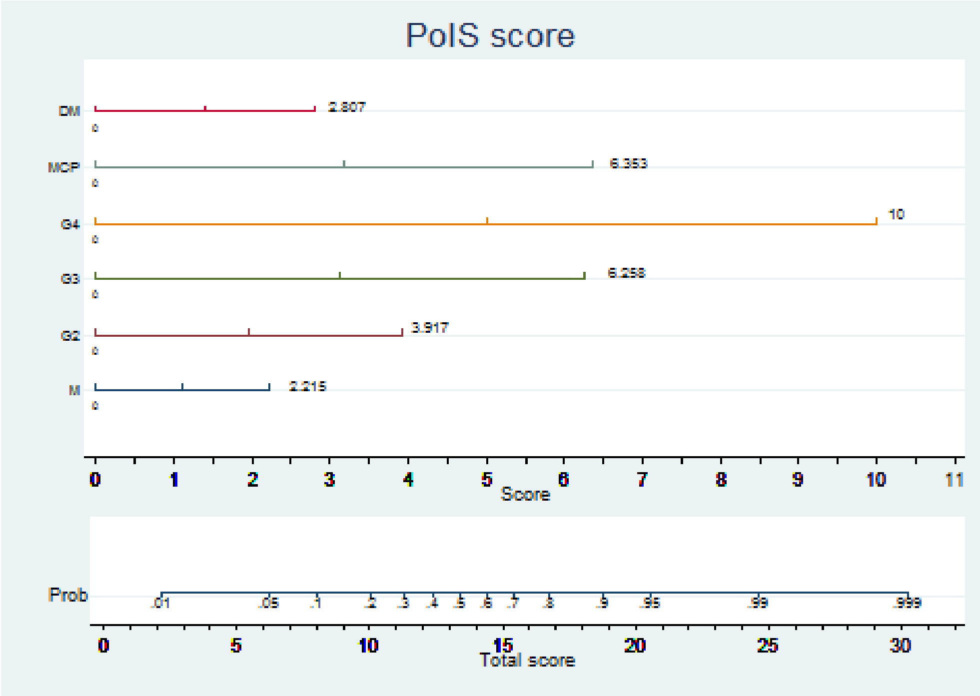

Figure3. *The nomogram of Harrell*

MCP=Myocardiopathy; M=Male; DM=Diabetes Mellitus; G2-G4=Surgical invasiveness grading.

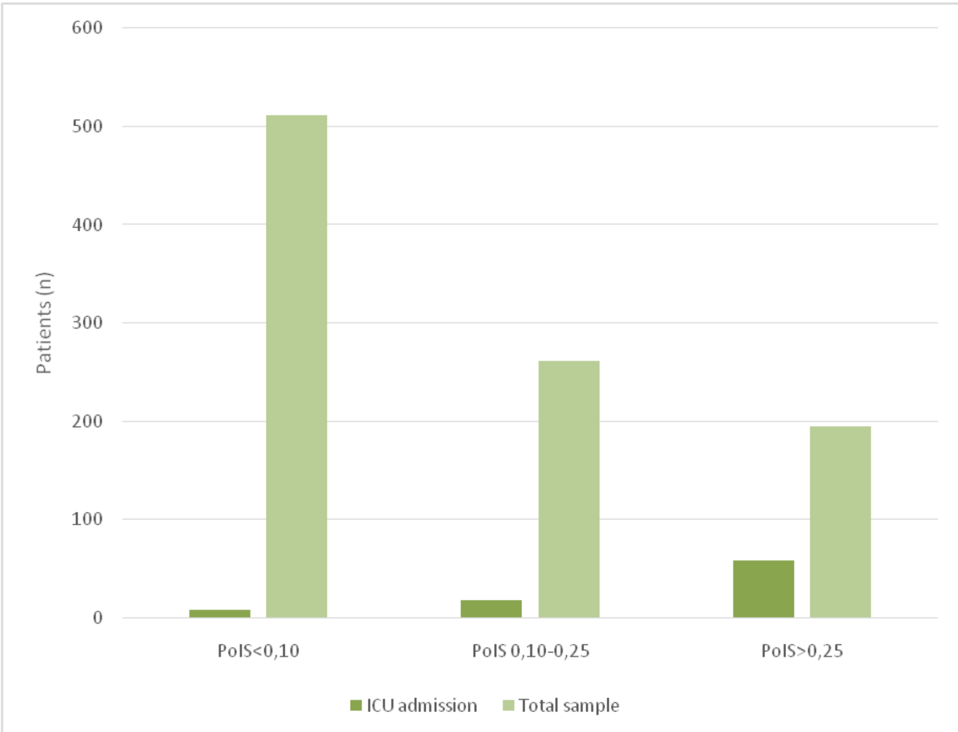

Figure4. *ICU admittedpatients' PoIS score*

Table2. *Results of prospective analysis*

PoIS score	N	Mean	Sd	p50	Min	max
Lowrisk (PoIS<0.1)	810	7.469877	7.05305	5.1	0.1	30.5
Intermediate risk (PoIS 0.1-0.25)	100	42.271	10.93289	38.2	38	64.3
High risk (PoIS>0.25)	57	81.39649	10.02182	85	66	98

Finally we compared PoIS-score with ASA-score and %Morbidity of POSSUM score. Statistical analysis showed significant difference between POIS and ASA (p<0,001) but no difference with POSSUM (p=0,653). Furthermore ROC curves showed that PoIS score and %Morbidity-POSSUM score curves were coincident (0.837 vs 0.840 respectively) and significantly better than the curve of ASA score (0.733), (Figure 5).

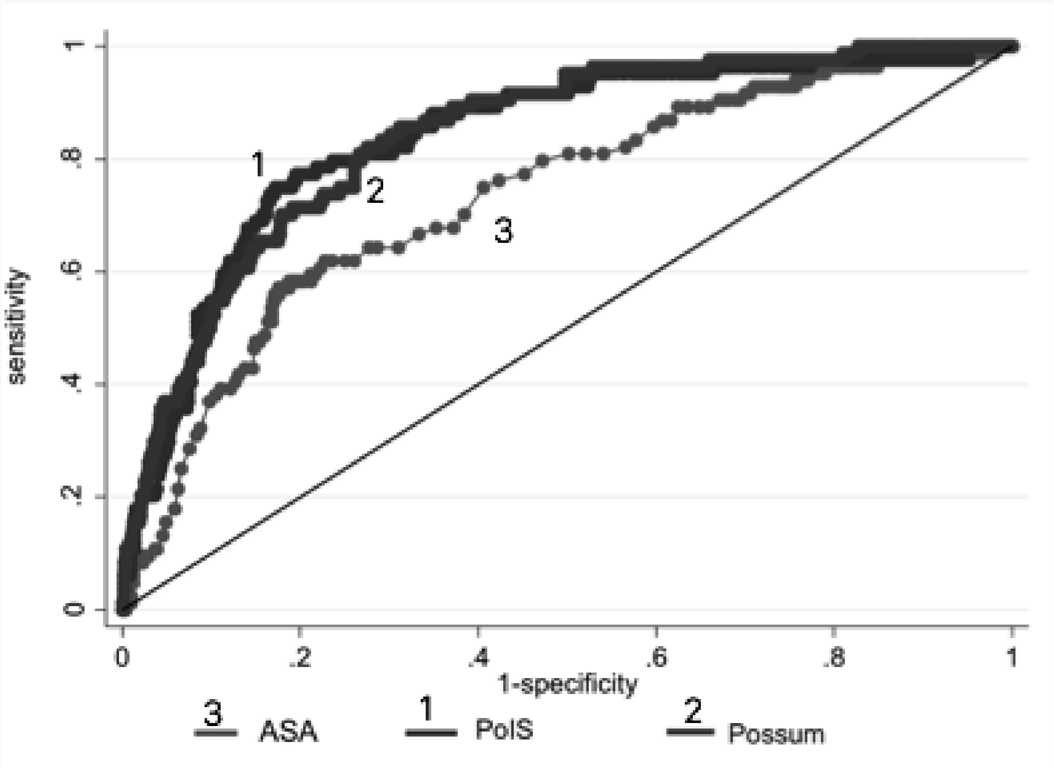

Figure5. *The ROC curves*

DISCUSSION

Our mixed trial (retrospective and prospective) showed that in our surgical population the main factors which may predict the needing of postoperative ICU admittance resulted the type of surgical operation, diabetes, history of heart disease and male sex. The combination of such markers in a score may provide the postoperative worthiness of intensive surveillance of surgical patients.

The main purpose of our investigation was not the searching for another risk-stratification system but to find a scoring tool which could detect the worthiness and the appropriateness of post-operative ICU admission. To hit the target we needed to search for the determining factors within our surgical population. Furthermore, our score should have not included intraoperative data, in order to manage the ICU-beds turnover planning. Since at our knowledge a similar scores does not exist, we compared PoIS score with two of the most used systems of perioperative risk stratification: ASA and POSSUM (specifically %Morbidity). ASA score showed a poor ability to identify individuals likely to experience complications in the postoperative period and didn't take into account for surgical procedure or individual differences concerning the appropriateness of postoperative care, [9]. In our study the re-evaluation of ASA score at ST1 resulted in disagreement with the preoperative scoring in a great portion of the sample. Furthermore, the two ASA evaluations were mostly different between the two highest frequency scoring classes: ASA 2 and ASA 3. We consider such results agree with the criticism against the subjectivity of the ASA scoring system. Nevertheless the strength of ASA score is its simplicity which made the system be applied worldwide.

POSSUM score could easily be used to provide analysis of the risk of mortality and morbidity in a wide range of general surgical procedures. The POSSUM original equation performed poorly in predicting the number of deaths especially in low-risk patients' classes, [7]. Our results show that the power of prediction of postoperative morbidity of PoIS and POSSUM resulted coincident and better than ASA score. Furthermore, the advantage of this new model is that it can be applied preoperatively and does not require the use of intraoperative data. Our purpose was also to create a software in which the equation of the new model can be inserted. This could allow PoIS to be calculated automatically during the preoperative outpatient assessment.

One of the most challenging issue of perioperative medicine is to adequately predict the needing of appropriate postoperative intensive care unit admission [10]. Given the scarce resource of ICU-beds, it is mandatory to predict at own best the needing of occupation of an ICU-bed postoperatively, particularly when surgical invasiveness is not so hard. At our knowledge, many scoring systems were created to evaluate surgical unit performance and/or to stratify the perioperative risk, [1,4,5,8,11-14], but none of them aim to measure the worthiness of postoperative ICU appropriateness.

Perioperative risk depends both on clinical and on no-clinical factors. One of these is the grading of surgical invasiveness. We declared that our surgical grading, even inspired to other similar classification, was “semi-arbitrary”. We blew-up the existing surgical grading, [2,3], according to how much demolitive is a type of operation and how much it lasts and whether it involves vital organs. We classified surgical procedures in five degree of invasiveness to make SI less subjective as possible. It was the most difficult step of our trial. Whether we were able to find a helpful tool to predict PoIS worthiness and consequently to better manage the turnover of ICU-beds and the correlated surgery planning, the next prospective validation step may show it or not.

Our trial has some limitations. First, it a single-center study. Then it need an in-our-hospital performance evaluation (the next step). Furthermore, we consider to test PoIS in a multi-center setting if it judged deserving after the prospective test. Second, the surgical grading is a questionable issue although inspired by similar classification we found in NHS website and European guidelines for no-cardiac surgery patient preoperative evaluation, [2,3]. Nevertheless, our surgical procedures grading is a work-in-progress pathway aimed to add new surgical procedures and/or shift some operations from a class to another when the continuous reviewing process will show it appropriate. Consequently, we are aware that our results, even promising, cannot be conclusive.

In conclusion, we developed a new scoring tool to predict the worthiness and appropriateness of ICU postoperative admission. If next prospective test of the PoIS will confirm its reliability, this new predictive score will be helpful for ICU-bed management.

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Citation: *Enrico G, Emanuela M, Grazia S et al. Postoperative Intensive Care Surveillance A Tool to Optimize ICU-Beds Management?. International Journal of Research Studies in Medical and Health Sciences. 2017;2(11):21-28.*

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