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Predictive power of modified frailty index score for pulmonary complications after major abdominal surgery in the elderly: a single centre prospective cohort study

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Abstract. – OBJECTIVE: The primary aim of this prospective cohort study was to evaluate the usefulness of the modified Frailty Index (mFI) score to predict postoperative pulmonary complications (PPCs) in elderly patients undergoing major open abdominal surgery. The secondary purpose was to compare the prediction power of mFI, Ariscat (Assess Respiratory Risk in Surgical Patients in Catalonia), and American Society physical status classification (ASA) scores.

PATIENTS AND METHODS: After local Ethical Committee approval, 105 patients aged ≥65 years undergoing open major abdominal surgery were enrolled. Clinical data were compared between patients with or without PPCs (including respiratory failure, aspiration pneumonia, pulmonary infection, pleural effusion, pneumothorax, atelectasis, bronchospasm or un-planned re-intubation). t-test or χ^2-test were performed for univariate analyses. Logistic regression analysis was used to identify independent predictors of PPCs. Non parametric ROC (Receiver Operating Characteristic) was used for cut-off calculation. AUCs (areas under ROC curve) of preoperative scores were compared using χ^2-test.

RESULTS: PPCs prevalence (11.3%) was associated with increased mFI, ASA, and Ariscat scores, greater age, hemoglobin levels <10 g/dl, peripheral oxygen saturation <95% (*p*=0.0001) and longer surgery duration. Logistic regression showed that mFI (*p*=0.0001) and Ariscat (*p*=0.04) were independent predictors of PPCs. The predictive power of mFI (AUC=0.90) was similar to that of Ariscat (AUC=0.81) (χ^2=2.53; *p*=0.11) but greater than that of ASA (AUC=0.69) (χ^2=9.85; *p*=0.002). An mFI≥0.18 was predictive of PPCs (sensitivity=90.91%; specificity=79.07%). An Ariscat score of 27 was the cut-off identified as determining factor for PPCs occurrence (sensitivity=90.91%; specificity=51.16%).

CONCLUSIONS: Elderly patients with an mFI ≥0.18 and/or an Ariscat score ≥27 were at higher risk of PPCs after open major abdominal surgery. More attention should be paid to these patients by implementing both strict monitoring and strategies for PPCs prevention in the perioperative period.

Key Words:
Abdominal surgery, Elective surgery, Patients-centered care, Prediction, Frailty, Personalized risk profile.

Introduction

Postoperative pulmonary complications (PPCs), with a prevalence in elective major abdominal surgery up to 23%, may adversely affect the outcome[1]. It has been recently demonstrated that frail patients were more likely to develop PPCs than non-frail patients in thoracic and orthopedic surgery[2,3]. Ariscat (Assess Respiratory Risk in Surgical Patients in Catalonia) score has been found to predict PPCs occurrence[4,5]. Both older age and an American Society physical status classification score (ASA) >2 have been advocated as predictors of PPCs in non-cardiac surgery[6,7].

The aim of this prospective cohort study was to evaluate the usefulness of an 11-item modified Frailty Index (mFI) score to predict PPCs occurrence in elderly patients undergoing major abdominal surgery. The secondary purpose was

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to compare its predictive power *versus* ASA and Ariscat scores.

Patients and Methods

After Local Ethical Committee approval (Fondazione Policlinico Universitario A. Gemelli IRCCS, Rome, Italy) and informed consent, 105 patients aged ≥65 years undergoing open major upper elective (partial/total colectomy; Hartmann's procedure; total/partial gastrectomy; liver resection; and pancreatic-duodenectomy) and lower (nephrectomy, prostatectomy or hysterectomy) abdominal surgery were screened for enrollment.

Exclusion criteria included: respiratory or muscular diseases, body mass index ≥35 kg/m^2, preoperative hemodynamic instability, severe cardiac disease, recent immunosuppressive medication (within the last 2 months), ASA>3, surgery duration>10 hours, planned intensive care unit admission, prolonged ventilation (>1h after the end of surgery) and perioperative blood loss >2000 ml.

Intraoperative monitoring included: 2-lead electrocardiography (II/V5), oxygen saturation (by pulse oximeter), invasive pressure monitoring (radial artery cannulation), neuromuscular monitoring (NMT neuromuscular transmission mechanosensor, GE Healthcare, UK), and Bispectral Index (BIS VistaTM, Aspect Medical System Inc, Norwood, MA, USA). Anesthesia induction was performed with propofol (2-3 mg/kg), fentanyl (2-3 mcg/kg) and rocuronium (0.6-1.2 mg/kg). Anesthesia maintenance was assured by sevoflurane at BIS guided concentration (40-60) and remifentanil (0.05-0.2 mcg/kg/min). For intraoperative curarization, rocuronium boluses were administered in order to maintain a moderate block (train-of-four, TOF<2). Lung protective ventilation was performed (tidal volume=6-8 ml/kg, respiratory rate=10-14 bpm and PEEP=5 cmH_2O). Hemodynamic derangements were prevented by Fluid therapy and administration of vasoactive drugs (norepinephrine 0.01-0.05 mcg/kg/min and/or dobutamine 5-8 mcg/kg/min). Fluid therapy was performed on the basis of dynamic indexes using the Vigileo-Flotrac system (Edwards/Lifescience, Irvine, CA, USA). Fluid therapy was defined as liberal when the hydric balance was >500 ml, restrictive when the hydric balance was <-200 ml, and zero balance when the hydric balance was between -200 and +200. Hemoglobin was kept ≥8 g/dl throughout surgery, and a forced-air warming system (Bair Hugger Model 505, Arizant Healthcare Inc, St. Paul, MN, USA) and a fluid warming device (enFlowR, BD, Franklin Lakes, NJ, USA) were used to maintain patients' temperature within the normal range. At the end of surgery, neostigmine or sugammadex were administered to achieve a TOF-ratio≥0.9. Postoperative analgesia was provided by an elastomeric pump containing tramadol (5 mg/ml; 2 ml/h), in addition to the wound infiltration, which was obtained with ropivacaine 0.2% (0.2 ml/kg).

PPCs were diagnosed based on one of the following new findings during the postoperative period: respiratory failure (SpO_2<90% despite supplemental oxygen or a PaO_2<60 mmHg or need for non-invasive or invasive mechanical ventilation); pulmonary infection (chest X-ray demonstrating unilateral or bilateral infiltrates); aspiration pneumonia; pleural effusion; pneumothorax; atelectasis on chest X-ray; bronchospasm; or un-planned urgent re-intubation.

Incentive spirometry was prescribed for all patients. Clinical data were compared between patients with and without PPCs. These include demographic information, medical history, preoperative risk scores (mFI, Ariscat, and ASA), surgery-related factors and outcome.

Statistical Analysis

Student's *t*-test or chi-square test were used as appropriate to compare all parameters between the two groups. Logistic regression was used to identify possible PPCs predictors, including only variables significant at univariate analysis. Cut-off of significant predictors was calculated using non-parametric ROC (Receiver Operating Characteristic) analysis and establishing a sensitivity >0.9. Areas under ROC curve (AUC) for mFI, Ariscat, and ASA scores were compared using chi-square test. A significance level of $p<0.05$ was used. Data were analyzed using the STATA/MP software, version 14.0 (StataCorp 2015, College Station, TX, USA).

Results

Eight patients were excluded for the following reasons: need for prolonged ventilation (n=3), surgery lasting more than 10 hours (n=3) and blood loss >2000 ml (n=2). 97 patients were finally included. Univariate analysis showed that PPCs prevalence was greater in patients with higher mFI (p=0.0001), Ariscat (p=0.0003) and ASA

Table I. Main pre-, intra-, and postoperative parameters in patients with and without PPCs.

	Patients with PPCs (n = 11)	Patients without PPCs (n = 86)	*t* or χ^2	*p*
Age, years	73.3 ± 7.1	69.7 ± 4.7	-2.25	0.03
Gender (M/F)	6/5	44/42	0.04	0.83
BMI, kg/m^2	27.4 ± 2.7	26.6 ± 5.2	-0.52	0.61
ASA (I/II/III)	0/7/4	11/69/6	9.91	0.007
ASA >2 (Yes/No)	4/7	6/80	9.11	0.003
MET (<4/4-7/>7)	4/7/0	15/70/1	2.30	0.32
Smoking (Yes/No)	2/9	6/80	1.62	0.20
Hb levels < 10 g/dL (Yes/No)	3/8	5/81	5.93	0.01
*SpO_2 < 95% (Yes/No)	7/4	5/81	30.08	0.0001
Ariscat	42.0 ± 10.7	27.4 ± 12.2	-3.78	0.0003
mFI (0/0.09/0.18/0.27/0.36)	0/1/2/7/1	11/58/10/7/0	35.83	0.0001
Approach (Upper/Lower)	7/4	36/50	1.87	0.17
Surgery duration, min	254 ± 105	198 ± 72	-2.31	0.02
Fluid therapy (L/R/Z)	7/0/4	32/3/51	2.98	0.22
Hospital stay duration, days	13.0 ± 4.6	7.7 ± 7.8	-2.16	0.03
Blood loss (ml)	360.0 ± 304.8	254.9 ± 252.8	-1.27	0.21
Vasoactive drugs (Yes/No)	1/10	4/82	0.39	0.53
Blood transfusion (Yes/No)	1/10	3/83	0.77	0.38
Reversal (N/S)	10/1	67/19	1.01	0.32
Mortality at 12 months	1/10	2/84	1.49	0.22

mFI: 11-item modified Frailty score; L: liberal, R: restrictive, Z: zero balance; N: neostigmine; S: sugammadex; Hb: hemoglobin; SpO_2: peripheral oxygen saturation; *on room air.

(*p*=0.007) scores, increased age (*p*=0.03), hemoglobin levels (Hb)<10 g/dl (*p*=0.01), peripheral oxygen saturation (SpO_2) <95% (*p*=0.0001) and longer surgery (*p*=0.02) (Table I).

Patients with PPCs (n=11) had the following drawbacks: pulmonary infection (n=5), atelectasis (n=3) or pleural effusion (n=3).

Logistic regression showed that mFI (*p*=0.0001) and Ariscat (*p*=0.04) were predictors of PPCs (Log-Likelihood=-12.8; Likelihood Ratio chi^2=43.0; *p*<0.0001). An mFI≥0.18 was predictive of PPCs (sensitivity=90.91%; specificity=79.07%). Moreover, an Ariscat score of 27 was identified as determinant cut-off for PPCs (sensitivity=90.91%; specificity=51.16%).

The predictive power of mFI (AUC=0.90) was similar to that of Ariscat (AUC=0.81; χ^2=2.53; *p*=0.11) but greater than that of ASA (AUC=0.69) (χ^2=9.85; *p*=0.002) (Figure 1). As regards outcome, there was a significant association between PPCs and length of stay (*p*=0.03).

Discussion

The main finding of this study was that frail patients (mFI≥0.18) were exposed to a higher risk of PPCs. An Ariscat score ≥27 fitted with PPCs prevalence.

mFI score (AUC=0.90) predicted PPCs with a similar power to that of Ariscat score (AUC=0.81) but in a more accurate manner than ASA (AUC=0.65).

Therefore, mFI and Ariscat have been shown to predict PPCs in elderly patients across major abdominal surgery regardless of age, surgery duration, and anesthesiological risk. As the items included in mFI and Ariscat scores are routinely obtained preoperatively, both these indexes can be readily calculated without additional testing for risk assessment[8]. The 11-item mFi, based on

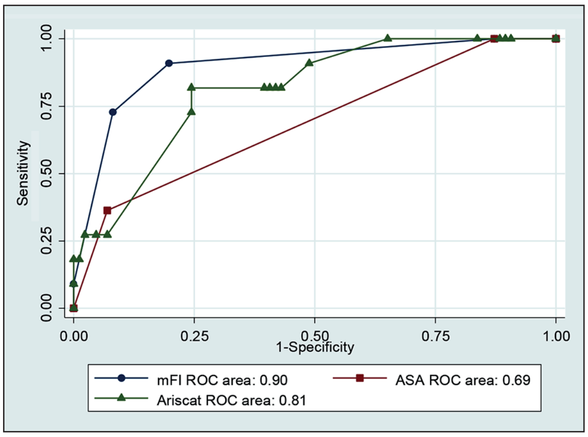

Figure 1. ROC areas of the three different preoperative risk score including Ariscat, mFI, and ASA.

a deficit-accumulation approach, is one of the simplest methods to assess frailty as well as one of the most investigated in relation to surgical outcome[9]. However, no previous studies have investigated its specific impact on PPCs in major abdominal surgery.

In this study, increased age – even if unsurprisingly significant at univariate analysis – was not an independent predictor due to the exclusion of young patients. Protective lung ventilation and neuromuscular block monitoring were foreseen as per protocol since both strategies may decrease PPCs[8,10,11]. Preoperative Hb levels <10 g/dl and SpO_2 on room air <95% were factors associated to high prevalence of PPCs since both are included in the Ariscat score[12]. However, a recent post hoc analysis of an international observational prospective study – including 8264 non-cardiac surgical patients – showed that moderate to severe anemia was not associated with increased PPCs[13]. Prophylactic non-invasive ventilation aimed at improving SpO_2 might be implemented in patients with an intermediate to the high predictive risk of PPCs, even if the quality of evidence is currently low[14]. Respiratory prehabilitation could play a key role in reducing PPCs risk[15]. A recent meta-analysis[14] showed that a tailored respiratory physiotherapy program performed under the supervision of a physiotherapist in the immediate pre- and postoperative period significantly decreases PPCs; however, further studies are warranted.

The main limit of this study is the inclusion of abdominal surgery with both upper and lower approaches. Another limit is no PPCs risk evaluation for each type of surgery due to the small sample size. Adherence incentive spirometry prescribed in the postoperative period was not evaluated. Lung expansion maneuvres had shown to reduce PPCs, especially when patients were instructed before surgery[8]. Finally, multicentre trials should be performed to evaluate the impact on the PPCs of interventions intended to modify specific frailty components.

Conclusions

An adequate and comprehensive evaluation of the potential risk factors related to PPCs – including mFI and Ariscat calculation – is required in elderly patients before major abdominal surgery. More attention should be paid to frail patients by implementing both strict monitoring and strategies for PPCs prevention.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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