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The Surgical Apgar Score: predicting postoperative complications following proximal femoral fracture surgery?

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Assinatura do Estudante

Assinatura do Orientador

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Resumo

Introdução: O Score de Apgar Cirúrgico (SAS) é um *score* de avaliação de risco peri-operatório, composto por 3 variáveis: a frequência cardíaca mínima, a tensão arterial média mínima e a estimativa das perdas hemorrágicas intraoperatórias. No geral, quanto menor o valor pontuado, pior será o prognóstico. Já validado em diversos campos cirúrgicos, o SAS permanece ainda controverso em contexto ortopédico. O objetivo deste estudo foi investigar se o SAS se relaciona com a ocorrência de complicações nos 30 dias pós-operatórios de correção de fratura do fémur proximal, uma das cirurgias ortopédicas urgentes mais comuns, podendo constituir uma ferramenta apuradora dos doentes que carecem de maior vigilância e cuidados pós-operatórios.

Metodologia: Estudo retrospetivo, aprovado pela Comissão de Ética do CHUPorto/ICBAS, que incluiu todos os doentes consecutivos submetidos a cirurgia de correção de fratura do fémur proximal entre janeiro e julho de 2019. Excluídos doentes sem registo dos dados de SAS. A informação dos doentes foi recolhida através do processo clínico eletrónico. Os doentes foram divididos em dois grupos, consoante tivessem tido ou não complicações nos primeiros 30 dias pós-operatórios, e os seus SAS comparados. Análise estatística realizada com recurso ao *software* SPSS versão 27.0.

Resultados: Quarenta e dois porcento (n=76) dos 181 doentes incluídos no estudo desenvolveram pelo menos uma complicação, nos primeiros 30 dias do pós-operatório. Quatro vírgula quatro porcento (n=8) faleceram nos 30 dias do pós-operatório. A idade média dos doentes foi de 79 anos, sendo que 30,9% (n=56) eram do sexo masculino. A insuficiência cardíaca (IC), o uso de pacemaker, doença renal crónica (DRC), doença pulmonar obstrutiva crónica (DPOC) e demência foram fatores significativamente associados à morbilidade pós-operatória. Os doentes com complicações pós-operatórias apresentaram também valores significativamente maiores de tempo de espera desde a admissão até à cirurgia e *American Society of Anesthesiologists Physical Status Classification System* (ASA-PS), e ainda alterações no estudo da coagulação pré-operatório. No entanto, não foi encontrada correlação significativa entre o SAS e ocorrência de complicações nos primeiros 30 dias de pós-operatório.

Discussão e Conclusões: Baseado neste estudo, concluímos que o SAS não permite prever a ocorrência de complicações nos 30 dias de pós-operatório em doentes submetidos a cirurgia de correção de fratura do fémur proximal. No futuro, estudos com desenho prospetivo e maior tamanho amostral podem auxiliar a melhor esclarecer o valor do SAS neste contexto.

Palavras-chave:
Score Apgar Cirúrgico, Fratura do fémur proximal, Morbilidade pós-operatória, Risco peri-operatório

Abstract

Backgroud: The *Surgical Apgar Score* (SAS) is a perioperative risk evaluation score, composed by 3 variables: intraoperative minimum heart rate, minimum mean arterial pressure and estimated blood loss. Generally, the lower the value scored, the worse the prognosis. It is already validated in multiple surgical fields, but SAS remains quite controverse in the orthopedic one. The main purpose of this study was to investigate if SAS relates with the occurrence of complications within the 30-day period following proximal femoral fracture surgery, one of the most common emergency orthopedic procedures, which might be helpful in distinguishing patients that require a more cautious post-operative follow-up.

Methods: Retrospective study, approved by the CHUPorto/ICBAS' Ethics Committee, including the patients submitted to proximal femoral fracture surgery between January and July of 2019. Patients with no information on SAS were excluded. The patient data was collected from the electronic clinical charts. Patients were divided in two groups, based on the occurrence of complications during the first 30 post-operative days and their SAS calculated. Statistical analysis was conducted using IBM Statistical Package for the Social Sciences (SPSS) version 27.0.

Results: Forty-two percent (n=76) of the 181 patients included in the study developed at least one complication during the first 30 post-operative days. Four point four percent (n=8) of the patients died on the same period. The patient's mean age was 79 years and 30,9% (n=56) of them were men. Heart failure (HF), pacemaker user, chronic kidney disease (CKD), chronic obstructive pulmonary disease (COPD) and dementia were significantly associated with post-operative morbidity. Patients with postoperative complications also presented higher values of waiting time for surgery since hospital admission and *American Society of Anesthesiologists Physical Status Classification System* (ASA-PS), as well as abnormal pre-operative coagulation studies. There was no significant correlation between SAS and the occurrence of complications during the first 30 post-operative days.

Conclusion: Based on this study, we conclude that SAS is not predictive of the development of complications in the first 30 post-operative days in patients submitted to proximal femoral fracture surgery. In the future, prospective-based studies with higher sample may better clarify the role of SAS in this context.

Key-words:
Surgical Apgar Score, Proximal femur fracture, Post-operative morbidity, Peri-operative risk

Lista de abreviaturas

AKI – Acute Kidney Injury
AUC – Area Under Curve
ASA-PS – American Society of Anesthesiologists – Physical Status
BMI – Body mass index
Bpm – beats per minute
CHUPorto – Centro Hospitalar Universitário do Porto
CKD – Chronic Kidney Disease
COPD – Chronic Obstructive Pulmonary Disease
EKG – Electrocardiography
Hb – Hemoglobin
HR – Heart Rare
INEM – Instituto Nacional de Emergência Médica
INR – International Normalized Ratio
LOS – Length of stay
MAP – Mean Arterial Pressure
mL – Milliliters
mmHg – millimeters of mercury
RBC – Red Blood Cell
ROC - Receiver Operating Characteristic
SAS – Surgical Apgar Score
UK – United Kingdom

Glossário

ASA-PS *score* – Escala de classificação de estado físico da Sociedade Americana de Anestesiologia, utilizada para avaliar o risco peri-operatório.

Delirium – Síndrome confusional agudo caracterizado por flutuações da cognição, atenção e consciência.

Post-operative morbimortality – Qualquer complicação, incluindo morte, independentemente da causa, ocorrendo nos primeiros 30 dias após cirurgia, dentro ou fora do hospital.

Substance use disorder – De acordo com a DSM-V, trata-se de uma condição crónica em que um padrão de uso de substância(s) descontrolado resulta em alterações físicas, psicológicas e sociais significativas no indivíduo, com o seu uso continuado apesar da existência de problemas relacionadas com a substância.

Surgical Apgar Score – S*core* calculado com base na menor pressão arterial média, menor frequência cardíaca e perdas hemáticas estimadas intraoperatórias, no decorrer da cirurgia. Escala de dez pontos em que um baixo valor identifica doentes com maior risco de desfecho desfavorável peri-operatório.

Índice

Esta dissertação/ tese de mestrado tem como base um artigo de investigação submetido à *Revista Española de Anestesiología y Reanimación* (REDAR).

O presente trabalho de investigação foi também apresentado em formato “poster” no Congresso Nacional da Sociedade Portuguesa de Anestesiologia de 2021.

Introduction

Proximal femoral fracture, or hip fracture, is a major worldwide public health problem. Its corrective surgery represents one of the most common emergency orthopedic procedures.[1] Silva J. et al[2] concluded that the number of proximal femoral fractures in Portugal increased from 508,49 to 628,39 fractures per 100,000 person-years between 2005 and 2013, affecting mostly people over 65 years of age and females.

The term "proximal femoral fracture" refers to a fracture of the femur delimited from the area of bone distal to the articular cartilage of the hip to a level of about 5 centimeters below the lower border of the lesser trochanter.[3] These fractures can be classified based on their relationship to the hip capsule: intracapsular, such as femoral neck fractures (subcapital, transcervical and basicervical, depending on the localization of the fracture line), or extracapsular, such as intertrochanteric and subtrochanteric fractures.[4]

Patients who have had a hip fracture are at risk for several complications: cardiovascular, pulmonary, thrombotic, infectious, bleeding and death.[4] Therefore, timely surgery, which is the mainstay of treatment, should occur within 48 hours of hospital admission. Early surgery has been associated with shorter postoperative complications and mortality.[5]

Surgical treatment may include internal fixation of the fracture or an arthroplasty, depending on the type of the fracture. Internal fixation is made using screws or pins, alone or in combination with a side plate applied to the femur, or by the use of an intramedullary nail with a cross screw inserted into the femoral head. Arthroplasty involves excision of the fractured area of bone and its replacement with a partial – hemiarthroplasty-, or a total hip prosthesis – total arthoplasty.[6]

The ideal anesthetic technique - general *vs*. regional anesthesia (including neuraxial block (spinal, epidural or both) and/or peripheral nerve block) – is still debatable.[7] Recent studies from Gremillet, C. and Jakobsson, J. G.[8], performed in a sweedish cohort, showed that neuraxial anesthesia was the most common technique used for acute hip fracture, and that 30-day mortality rate was not affected by the type of anesthetic technique used, despite being influenced by patient factors (i.e. increasing age, ASA-PS score and male gender). On the other hand, other studies suggest that the length of hospital stay and the in-hospital mortality is shorter in the neuraxial anesthesia group.[9]

There's a wide range of complications observed up to 30 days after hip fracture surgery. Part of them are surgery procedure-related, such as wound infection and loss of reduction.[10] Furthermore, because most of the patients going through this procedure are frail elderly persons[2], the most commonly encountered complications are non-surgical, such as cognitive alterations (delirium), cardiopulmonary affections (pneumonia, heart failure), venous thromboembolism, gastrointestinal tract bleeding, urinary tract complications (acute

kidney injury), hematological (perioperative anemia), electrolytic and metabolic alterations and pressure ulcers.[6,10]

Several clinical risk scoring systems exist in the surgery and anesthesiology fields as an attempt to predict perioperative morbimortality risk.[11] The Surgical Apgar Score (SAS) is a simple, objective and economical ten-point postoperative prognostic scoring system-based on three intraoperative variables: lowest heart rate, lowest mean arterial pressure and estimated blood loss. (Table I) This last one is estimated based on both the weight of gauze used and the volume of the suction obtained at the end of the surgery.[12]

SAS was first validated by Gawande A. A. et al[13] on general and vascular surgery in 2007, showing a strong correlation with the occurrence of major complications or death within 30 days of surgery: a lower sum of points predicts a poorer prognosis. Unlike other scoring systems, SAS has the advantage of not being dependent on biochemical investigations, clinical assessment, acute or chronic disease classification, or depend on the timing of the surgery (elective, urgent, emergent).[14]

On the orthopedics field, there are some controversy study findings about the validation of the SAS on predicting major postoperative complications and death. Urrutia J. et al[15] assembled that the score system did not have a good correlation on general orthopedic surgery, but it was useful in the subgroup of patients undergoing spine surgery**.** On the other hand, more recent research defined that calculating SAS shows how intraoperative events affect postoperative outcomes on trauma hip fracture surgery.[16]

Although it lacks utility in the preoperative setting, authors have proposed that SAS should be used to aid communication between care teams and to direct the clinical management in the postoperative phase.[17]

The purpose of this study was to retrospectively evaluate the predictive value of the SAS to accurately predict the occurrence of complications in the 30-day postoperative period, including death, in the setting of orthopedic procedures, specifically in proximal femoral fracture surgery. As secondary goal other clinical, laboratorial and tests characteristics for complications after proximal femoral fracture surgery were searched.

Methods

Subjects and procedures

Cross-sectional retrospective study including every consecutive patient who underwent surgery correction of proximal femoral fracture from 1st January 2019 to 22nd July 2019 in *Centro Hospitalar Universitário do Porto* (CHUPorto).

The study was approved by the Hospital Boards and Ethics Committee with the approval number 2020-296(277-DEFI-240-CE).

For each patient, data was collected from the electronic clinical chart database. Demographic data collected included age, sex, literacy, BMI, ASA-PS and medical comorbidities. Exclusion criteria included patients with intraoperative dead and patients without data concerning SAS variables.

We subdivided the other variables into 4 groups: prehospital, pre-operative, intra-operative and post-operative. The prehospital group variables included the mechanism of fracture and mean of transport to the hospital. The pre-operative group variables included the Manchester screening scale code, the time between hospital admission and surgery, blood analysis results (hemoglobin, hematocrit, platelets, urea, creatinine, potassium, coagulation disorders) and the EKG results at admission. Concerning the intra-operative variables group, it included the duration and type of surgical procedure, the category of fracture, type of anesthesia, opioids used and the Surgical Apgar Score (intraoperative minimum heart rate, minimum mean arterial pressure and estimated blood loss). The last variable group, the post-operative one, included the length of stay, the complications during the 30-day period following the surgery and death within the same period.

Complications registered during the first 30 days post-operative were based on previous and similar studies, which included pneumonia, sepsis, blood loss requiring ≥ 2 units of RBC transfusion, urinary tract infection, delirium, reintervention, avascular necrosis, myocardial infarction, cerebral ischemia, pulmonary thromboembolism, deep vein thrombosis, surgical site infection, acute kidney injury and death.

Statistical analysis

Patients were separated into two main groups, those who had at least one complication during the 30-day post-operative period (morbidity group) and those who had not (non-morbidity group).

Each item from the SAS and the SAS itself were compared between the two groups, as well as other variables from the four variables groups.

On a first approach, for the descriptive statistics, qualitative variables were studied using the absolute and relative frequencies, and for quantitative variables, the mean, standard

deviation, minimum and maximum values were calculated according to the normality of the distribution.

In order to study the correlation between the two groups with other variables, a Student T test was used for the quantitative variables and a χ^2 test for qualitative variables.

We assessed the power of a model to predict postoperative morbimortality within the first 30 days after the femoral neck fracture surgery based on SAS and each item of it by obtaining the respective receiver operative characteristic (ROC) curves and then calculating the area under the receiver operating characteristic curve operative (AUC). An area under the curve of >0.70 was considered acceptable.

Statistical analysis was conducted using IBM Statistical Package for the Social Sciences (SPSS) version 27.0. A p value < 0.05 and a confidence interval of 95% were considered significant.

Results

One hundred and eighty-one patients were included in the study. The initial sample included 182 patients, of which one was excluded because there were no data concerning SAS variables. Mean age was of 79±12 (range 42-99) years and there was a total of 125 women (69,1%) (Table II describes demographic data). The three most common comorbidities present were systemic arterial hypertension (63%), chronic kidney disease (24%) and diabetes (23%). Ninety-eight patients (54,1%) had an ASA-PS score of III and 26 patients (14,4%) had a score of IV or more.

Concerning fracture mechanism, the incidence of fall from standing height was the highest, accounting for 169 cases (93%), The majority of patients were transported to the hospital through emergency vehicle (INEM) (77%). Table III sums up the results of the prehospital variables.

Table IV shows the baseline laboratory workup on admission. On hospital admission, 153 patients were classified as “urgent” on the Manchester Triage Scale. The mean waiting time for surgery since admission was 4,3 ± 3,5 days.

Concerning types of treatment, osteosynthesis was the most common (74%), with trochanteric being the most usual fracture location (55,8%). Regarding anesthesia, the combined and spinal ones were the most commonly applied (49,7% and 37,0%, respectively), with intravenous opioids being the most common form used. The mean surgery time was 75 ± 39 minutes.

The mean SAS score was 7,4±1,5 (range 3-10), with each component as follows: estimated blood loss (139±136 mL); lowest MAP (66±13 mmHg); lowest HR (65±13 bpm).

Seventy-six patients (42%) developed at least one complication on the 30-day post-operative period, with urinary tract infection (n=32), the need of ≥ 2 units of RBC transfusion on the postoperative period (n=20) and AKI (n=14) being the most common forms of morbidity. In total, 123 complications were registered. The 30-day mortality rate was 4,4% (n=8).

We then compared clinical, laboratorial and tests characteristics of all group variables between the 76 patients with and the 105 without postoperative morbidity. There were significant differences between the two groups in systemic arterial hypertension, heart failure, CKD, COPD, use of pacemaker and dementia as comorbidities, the ASA-PS score, waiting time for surgery and changes in coagulation studies on admission. The prevalence of CKD (36%), heart failure (30%), dementia (28%), COPD (22%) and pacemaker use (11%) were significant higher in the group with morbidity than in the without morbidity group (15%, 16%, 12%, 7% and 3%, respectively). Patients with associated morbidity presented statistically significant higher ASA-PS score. The presence of systemic arterial hypertension as a comorbidity was significant higher in the group without complications. Patients with

morbidity waited a significant higher period for surgery (4,9 ± 4,5 days) than the non-morbidity group (3,8 ± 2,4 days) and, on admission, changes in coagulation where significantly more common in the morbidity group.

Table VI shows the results of our comparison of the SAS values between the two groups. The SAS on the group with morbidity (7,3 ± 1,6; range 4-10) was not significantly different from the without morbidity group (7,5 ± 1,4; range 3-10). Each component of the SAS score was compared as well, showing no significant differences either.

Table VIII contains the AUC to predict the 30-day morbidity for each model. Neither SAS (AUC 0,522), nor each item itself (AUC 0,520; 0,500; 0,538) showed an AUC considered acceptable to predict postoperative complications. The highest value obtained (AUC 0,663) was from ASA-PS score, being the best analyzed variable to predict postoperative complications.

Discussion

Demographic data of patients submitted to proximal femoral fracture surgery:

In our study, the sample had a mean age of 79 years and 69,1% were women, which is similar to a previous portuguese study that analyzed 101.436 patients with proximal femoral fracture, with a mean age of 79,32 ± 12,33 years and a female prevalence of 74,5%. Several factors may explain this female predominance, namely the occurrence of postmenopausal osteoporosis and other genetic factors.[2]

We found significant differences concerning comorbidities between the two groups (with and without morbidity in the postoperative period), specifically: the prevalence of CKD, HF, dementia, COPD and pacemaker use was higher in the group with postoperative complications. These results corroborate several other studies aiming to predict the impact of comorbidities on postoperative complications and mortality after hip fracture. Roche J J W. et al[18] established that cardiovascular disease and chronic lung disease predispose patients to serious postoperative complications. Regarding CKD, Robertson L. et al[19] concluded that the incidence of hip fracture was higher in individuals with CKD compared with those with normal estimated glomerular filtration rate (eGFR), most probably due to metabolic disfunction related to abnormalities in the parathyroid–calcium–phosphate axis as a result of reduced kidney function. Dementia and hip fractures are two main conditions, both seen primarily in older adults. It's possible that the postoperative complications are higher in patients with dementia due to difficulties inherent to postoperative rehabilitation: they often have difficulty following the instructions of the physical therapist; delayed ambulation may lead to postoperative UTI or even septicemia; difficulty in eating and swallowing result in malnutrition and aspiration pneumonia, respectively, among other factors. [20] On the other hand, our study showed that systemic arterial hypertension was significant higher on patients without postoperative complications, contradicting the results presented by Wei J. et al.[21]

Morbidity and mortality rates following proximal femoral fracture surgery:

We found a 30-day postoperative morbidity and mortality rate of 42% and 4,4%, respectively. Kotera A. et al[12] conducted a similar study in Japan showing a 27,0% 30-day morbidity rate and 0,2% 30-day mortality rate. Barbosa T.A. et al[22] led a more extensive follow-up study after proximal femoral fracture surgery showing 57,0% 1-year morbidity rate and 7,7% 30-day mortality rate. This empathizes how femoral neck fractures can be an important cause of postoperative mortality[23], with literature revealing very discrepant values.

The three most common complications found in our study were urinary tract infection, blood loss requiring ≥ 2 units of RBC transfusion and acute kidney injury. During surgery or even at admission, due to immobilization, most patients were subjected to indwelling urinary

catheterization inserted in order to drain urine during and/or after procedure, and even some anesthesia options (as long term neuraxial opioids) can lead to urinary retention, both of which are major risk factors for post-operative UTI. Like any other surgery, blood loss often results in post-operative decrease in Hb values, requiring RBC transfusion in order to maintain organ perfusion and oxygenation, with goals of Hb above 7-9 g/dL according to patients' morbidities, hemodynamic and clinical signs. Finally, the pathophysiology of postoperative AKI is complex and involves prerenal, intrinsic and postrenal mechnisms.[24] However, in a similar study, the most prevalent post-operative complications were pneumonia, DVT and surgical site infection.[12]

Scores to predict complications:

Stratifying the postoperative risk for frail patients carries great importance to adequate postoperative level of care, strategies of treatment and monitoring. In 2015, Karres J. et al[25]' study aimed to evaluate different prediction models of complications following proximal femoral fracture surgery, such as the Charlson Comorbidity Index (CCI), Orthopaedic Physiologic and Operative Severity Score for the enUmeration of Mortality and Morbidity (O-POSSUM), Estimation of Physiologic Ability and Surgical Stress (E-PASS), a risk model by Jiang et al., the Nottingham Hip Fracture Score (NHFS), and a model by Holt et al. All these models achieved an AUC greater than 0.70, reveling an acceptable discriminative power, except for O-POSSUM. These models assemble pre-operative variables, such as age, comorbidities, lab values on admission and others. That being said, they can estimate the mortality risk for the hip fracture patient at the time of admission and may even be of assistance in clinical decision making. However, they are time-consuming, so not useful to use on emergency setting. Furthermore, some variables may not be exhaustively asked to patients on admission and some comorbidities may be undiagnosed.

The perfect prediction score to use in the emergency setting would be applicable preoperatively, to allow to decide even about the surgical treatment strategy in a simple, quick and easy way. Undoubtedly, with a high prediction capacity of morbidity and mortality on postoperative period. However, as such score isn't available, it's important to identify simple scores already in use in practice or newly developed to predict postoperative complications for those patients. It would allow surgeons and anesthesiologists to consistently identify perioperative patients who are at higher risk of major complications or death, and test standards and innovations to improve our ability to save such patients.

Surgical Apgar Score:

SAS is a simple score proposed by the World Health Organization on their worldwide innitiative "Safe Surgery Saves Lives" as a quality improvement tool to be used as an universal outcome predictor.[26] As said above, Gawande A. A. et al[13] suggested a strong correlation between SAS with the occurrence of major complications or death within 30 days

of general and vascular surgery. However, it remains controversial on the orthopedic field, with Kotera et al[12] determining that the SAS can accurately predict morbimortality after hip fracture surgery.

Comparing our results with Kotera et al, our overall mean SAS was 7,4 ± 1,5 (range 3-10), similar to Kotera's mean SAS of 7,5 ± 1,1 (range 4–10). The mean SAS value of 7,3 ± 1,6 (range 4-10) was obtained on the group with morbidity, which was not significantly different from the without morbidity group (7,5 ± 1,4; range 3-10). Each component of the SAS score was compared as well, showing no significant differences either. We do not have other studies' results to compare, because Kotera's study compared the SAS between 90-day postoperative survivors and non-survivors, and not patients with and without 30-day postoperative complications like we did.

Despite being originally used as a model with the power to predict 30-day postoperative complications, Kotera et al. used the SAS to predict 90-day mortality instead, because their 30-day mortality rate was too low (0,2%). That being said, Kotera proposed the SAS had the ability to predict 90-day postoperative mortality (AUC 0,76) and it shows to be a better predictor when used in combination with the patient's preoperative physical status (e.g. assessing the power of SAS combined with comorbidities in order to predict 90-day post-operative morbidity).

However, we concluded that the SAS cannot accurately predict 30-day postoperative complications following proximal femoral, with an AUC of 0,522, corroborating the conclusion presented by Thorn C. C. at al[27] and Urrutia et al[15]'s studies, where SAS appeared to have a limited role in predicting 30-day complications after orthopedic surgery (AUC 0,62 and 0,59, respectively). It could be theorized that the limited efficacy to predict post-operative complications with SAS in this specific cohort could be secondary to a smaller complication rate compared to general and vascular surgery.[15]

Other risk factors:

We analyzed other variables that showed to be statistically different between the groups with and without morbidity. A statistically significant higher ASA-PS score was seen on patients with postoperative morbidity. The purpose of this system is to offer clinicians a simple categorization of a patient's preoperative physiological status that can be helpful in predicting operative risk, with a higher ASA-PS score having a poorer status.[28]

We also concluded that patients with postoperative morbidity had a larger waiting time for surgery since admission (4,9 ± 4,5 days), with UK literature revealing that surgery should occur within the first 48h after patient admission.[5] Nevertheless, according to N. Morrissey et al, delaying proximal femoral fracture surgery beyond 24h after admission the risk of mortality increased by 1.8% for every hour of delay.[29] Abnormal coagulation studies were also statistically different in patients with post-operative morbidity on our study. Validating

this hypothesis, recent studies suggest that preoperative platelet thresholds of <100,000/μL and INR thresholds of 1,5 serve as an important risk factor for complications after hip fracture surgery.[30]

Study limitations:

Our study presents some important limitations. As a study with a retrospective design, missing data on complications may have occurred, namely on those not so commonly assessed as cognitive impairment after surgery and post-operative delirium. On the other hand, SAS parameters, especially blood loss may be sometimes erroneously estimated, as the weighting of gauzes used is not a routine in a normal surgery due to lack of time, so this estimative could be rough. After discharge, patient's follow-up was also only accessed on the postoperative orthopedic appointment, around one month after surgery, in some way scarce and again some complications could be missed.

Study strengths:

It was the second study, according to our research, to explore the utility of SAS in the setting of prediction of postoperative complications after femoral fracture surgery, the first in portuguese population.

It was an opportunity to audit the fulfillment of SAS in clinical records (only one patient excluded for lack of data, so an adhesion rate of 99,55%), as well as an opportunity to audit our morbidity and mortality after this frequent orthopedic and surgical emergency.

Future considerations:

With a considerable postoperative morbidity rate of 42% presented on our study, it would be opportune to display our results to orthopedic and anesthesiology clinicians in order to raise awareness on the identification of patients who are likely to need further perioperative surveillance. As a secondary goal, alert them to the importance of SAS rigorous fulfillment and parameters estimation for a better prediction accuracy and to perform a better and safer surgery, according to WHO Safe Surgery protocol, as well as identification and registration of clinical complications on electronic database.

In the future, prospective-based studies with a higher sample may better clarify the role of SAS in this context, that remains controversial.

Other perioperative scores should also be studied and tested as predictors of morbimortality in this surgery, as this is the most common emergency surgery, and compromises a very frail population.

Conclusion:

Being one of most common emergency orthopedic procedures, our study revealed a 42% and 4,4% 30-day morbidity and mortality rates, respectively, following proximal femoral fracture surgery in our center. In order to reduce this numbers, we aimed to predict the occurrence of complications using the Surgical Apgar Score as predictive model. This

score, an easily computed outcome predictor based on intraoperative blood loss, heart rate and blood pressure, is recommended by WHO Safe Surgery Guidelines. However, it showed not to be a good model for prediction of complications following this specific surgery in our sample. Studying and identifying the risk factors responsible for postoperative complications following proximal femoral fracture surgery patients could prove useful, such as ASA-PS score and waiting time for surgery. In the future, studying other complications predictive models could be an asset for managing these risk factors could result in lower postoperative morbidity and mortality rates. As well as a reduction of the cost and the dissatisfaction that naturally comes with it.

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Table I. Surgical Apgar Score

	0 points	1 point	2 points	3 points	4 points
Estimated blood loss, mL	>1000	601-1000	101-600	<100	-
Lowest mean arterial pressure, mmHg	<40	40-54	55-69	>70	-
Lowest heart rate, bpm	>85	76-85	66-75	56-65	<55

The lower the score (sum of points), the poorer the prognosis.

Table II. Patients demographic data and comparison of clinical characteristics between patients with and without morbidity

	All patients (n=181)	With morbidity (n=76)	Without morbidity (n=105)	*p* value
Age (years)	79±12 (42-99)	80±13 (42-99)	78±12 (44-98)	0,365
Male	56 (30,9%)	23 (30,3%)	33 (31,4%)	0,867
BMI (n=107)	25,2 ± 5,0	25,5 ± 4,7	25,0 ± 5,2	0,525
Literacy (n=51)				
<9th grade	42	17	25	0,633
9th-12th grade	6	3	3	
University degree	3	2	1	
Comorbidities				
Osteoporosis	13 (7%)	4 (5%)	9 (9%)	0,395
Systemic arterial hypertension	114 (63%)	41 (54%)	73 (70%)	0,032*
Heart failure	40 (22%)	23 (30%)	17 (16%)	0,024*
Dysrhythmia	31 (17%)	14 (18%)	17 (16%)	0,694
Pacemaker	11 (6%)	8 (11%)	3 (3%)	0,033*
Previous stroke	24 (13%)	10 (13%)	14 (13%)	0,973
CKD	43 (24%)	27 (36%)	16 (15%)	0,002*
COPD	24 (13%)	17 (22%)	7 (7%)	0,002*
Substance-use disorder	10 (6%)	5 (7%)	5 (5%)	0,597
Diabetes	42 (23%)	18 (24%)	24 (23%)	0,896
History of neoplasia	22 (12%)	9 (12%)	13 (12%)	0,913
Rheumatoid arthritis	3 (2%)	0 (0%)	3 (3%)	0,137
Valvopathy	19 (11%)	9 (12%)	10 (10%)	0,616
Dementia	34 (19%)	21 (28%)	13 (12%)	0,010*
ASA-PS score				
I	2	0	2	0,001*
II	55	13	42	
III	98	44	53	
IV	25	17	8	
V	1	1	0	

*p<0.05: statistically significant difference between morbidity and non-morbidity groups. BMI: Body Mass Index; CKD: Chronic Kidney Disease; COPD: Chronic Obstructive Pulmonary Disease; ASA-PS: American Society of Anesthesiologists Physical Status Score

Table III. Comparison of pre-hospital variables between patients with and without morbidity

		All patients (n=181)	With morbidity (n=76)	Without morbidity (n=105)	*p* value
Fracture mechanism	Fall from standing height	169 (93%)	72 (95%)	97 (92%)	0,302
	Higher height fall	1 (1%)	1 (1%)	0 (0%)	
	Road accident	3 (2%)	0 (0%)	3 (3%)	
	Others	8 (4%)	3 (4%)	5 (5%)	
Type of transport	Non-defined	15 (8%)	2 (3%)	13 (12%)	0,188
	From home	5 (3%)	2 (3%)	3 (3%)	
	INEM	140 (77%)	61 (80%)	79 (75%)	
	From another hospital	17 (9%	9 (12%)	8 (8%)	
	From another CHUPorto's department	4 (2%)	2 (3%)	2 (2%)	

Table IV. Comparison of pre-operative variables between patients with and without morbidity

		All patients (n=181)	With morbidity (n=76)	Without morbidity (n=105)	*p* value
Manchester Triage System	Blue	1	1	0	0,345
	Green	3	1	2	
	Yellow	153	62	91	
	Orange	22	10	12	
	Red	2	2	0	
Waiting time for surgery (days)		4,3 ± 3,5	4,9 ± 4,5	3,8 ± 2,4	0,039*
Hemoglobin (mg/dL)		11,9 ± 2,0	11,5 ± 2,3	12,1 ± 1,7	0,061
Hematocrit (Htc)		35,0 ± 5,6	34,1 ± 6,9	35,7 ± 4,4	0,092
Platelets		227 ± 78	214 ± 76	237 ± 79	0,056
Urea		58 ± 34	63 ± 40	54 ± 28	0,075
Creatinine		1,17 ± 0,99	1,33 ± 1,13	1,06 ± 0,85	0,063
Potassium		4,30 ± 0,63	4,32 ± 0,64	4,28 ± 0,61	0,682
Coagulation changes		56 (31%)	30 (40%)	26 (25%)	0,035*
EKG	No changes	109	41	68	0,296
	With SV changes	60	30	30	
	Conduction changes	12	5	7	
	Others	0	0	0	

*p<0.05: statistically significant difference between morbidity and non-morbidity groups.

Table V. Comparison of intra-operative variables between patients with and without morbidity

		All patients (n=181)	With morbidity (n=76)	Without morbidity (n=105)	*p* value
Type of anesthesia	General	24	9	15	0,802
	Spinal	67	30	37	
	Combined	90	37	53	
Type of treatment	Osteosynthesis	134	59	75	0,348
	Arthroplasty	47	17	30	
Fracture location	Trochanteric	101	47	54	0,330
	Neck	71	25	46	
	Subtrochanteric	9	4	5	
Intraoperative opioids	Intravenous	117	47	70	0,533
	Intrathecal lipophilic opioids	31	16	15	
	Intrathecal morphine	2	0	2	
	Both	10	5	5	
	None	6	3	3	
Sedation (when regional anesthesia) n=55	With	12	4	8	0,253
	Without	43	23	20	
Surgery duration (min.)		75 ± 39	74 ± 42	75 ± 38	0,770

Table VI. Comparison of the Surgical Apgar Score (SAS) and its parameters between patients with and without morbidity

	All the patients (n=181)	With morbidity (n=76)	Without morbidity (n=105)	*p* value
Estimated blood loss (mL)	139 ± 136	140 ± 127	139 ± 143	0,974
Lowest mean arterial pressure (mmHg)	66 ± 13	65 ± 12	66 ± 13	0,880
Lowest heart rate (bpm)	65 ± 13	66 ± 15	64 ± 12	0,256
Surgical Apgar Score (points)	7,4±1,5 (3-10)	7,3±1,6 (4-10)	7,5±1,4 (3-10)	0,360

Table VII. Proportion of post-operative complications within the first 30-days of postoperative period

Complication	n (% of the 30-day post-operative complication)	N of complications in patients who died (n=8)
Urinary tract infection	32 (26%)	2
Requiring ≥ 2 units of RBC transfusion	20 (16%)	1
Acute kidney injury	14 (11%)	2
Delirium	13 (11%)	3
Pneumonia	12 (10%)	1
Surgical site infection	7 (6%)	-
Sepsis	5 (5%)	1
Reintervention	5 (5%)	-
Cerebral ischemia	3 (2%)	-
Cardiorespiratory arrest	1 (1%)	1
Myocardial infarction	0	-
Deep vein thrombosis	0	-
Pulmonary thromboembolism	0	-
Non-union	0	-
Avascular necrosis	0	-
Others	11 (9%)	2
Total	123	-

RBC: Red Blood Cell.

Table VIII. Area under the receiver operating characteristic (ROC) to predict the 30-day morbidity for each model

Item	**AUC**
Estimated blood loss (mL)	0,520
Lowest mean arterial pressure (mmHg)	0,500
Lowest heart rate (bpm)	0,538
Surgical Apgar Score (points)	0,522
ASA-PS score	0,663
Waiting time for surgery (days)	0,579

Lista de figuras

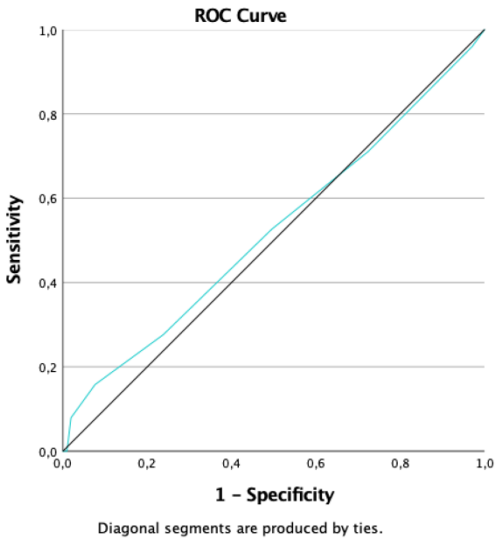

Figure 1. ROC curve for the **SAS** as predictor of major complications. The area under the curve corresponds to the C-statistic, which was 0.522.

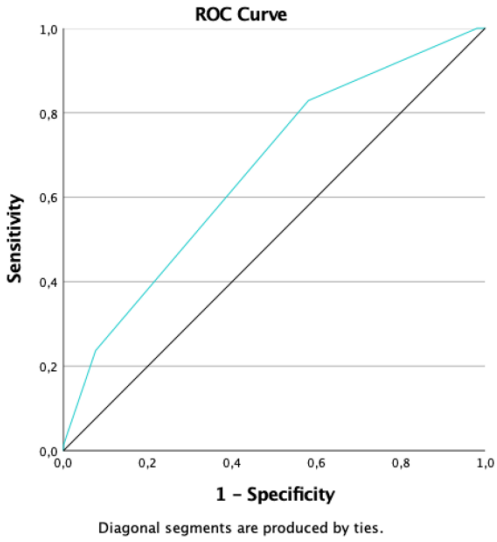

Figure 2. ROC curve for the **ASA-PS** as predictor of major complications. The area under the curve corresponds to the C-statistic, which was 0.663.