

Risk factors for pulmonary complications after abdominal surgery

Factores de riesgo de complicaciones pulmonar después de la cirugía abdominal

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Abstract

While pulmonary complications are infrequent compared to infectious complications after abdominal surgery, they significantly increase the patients' morbidity and cost of care. Moreover, postoperative pulmonary complications (PPC) include other elements beyond pneumonia. These conditions encompass atelectasis, pneumothorax, acute respiratory distress syndrome, pulmonary emboli, and many others. Considering the substantial impact of PPC, preventive measures are highly suggested to increase patients' survival rates. Proper risk management can significantly influence the outcomes of surgical procedures. Evidence suggests that preoperative preventive measures positively influence surgical outcomes. Nonetheless, risk factors for PPC are highly heterogeneous and difficult to fit within only one predictive model. As a result, currently available predictive models have a narrow perspective regarding this issue. Further research is needed to adapt and optimize older predictive models, or to develop new ones. An increased pool of predictive tools would allow a more precise analysis of risk factors, in order to implement suitable measures. This review aims to identify risk factors independently associated with the appearance of PPC.

Keywords: Postoperative pulmonary complications, surgical complications, abdominal surgery, respiratory complications, risk factors.

Resumen

Si bien las complicaciones pulmonares son poco frecuentes en comparación con las complicaciones infecciosas después de la cirugía abdominal, aumentan significativamente la morbilidad y el costo de la atención de los pacientes. Además, las complicaciones pulmonares posoperatorias (CPP) incluyen otros elementos más allá de la neumonía. Estas afecciones abarcan atelectasia, neumotórax, síndrome de distrés respiratorio agudo, embolia pulmonar y muchas otras. Teniendo en cuenta el impacto sustancial de la CPP, se recomiendan encarecidamente medidas preventivas para aumentar las tasas de supervivencia de los pacientes. La gestión adecuada de riesgos puede influir significativamente en los resultados de los procedimientos quirúrgicos. La evidencia sugiere que las medidas preventivas preoperatorias influyen positivamente en los resultados quirúrgicos. No obstante, los factores de riesgo para CPP son muy heterogéneos y difíciles de encajar en un solo modelo predictivo. Como resultado, los modelos predictivos disponibles actualmente tienen una perspectiva estrecha sobre este tema. Se necesita más investigación para adaptar y optimizar modelos predictivos más antiguos o desarrollar otros nuevos. Un mayor conjunto de herramientas predictivas permitiría un análisis más preciso de los factores de riesgo para implementar medidas adecuadas. Esta revisión tiene como objetivo identificar factores de riesgo asociados de forma independiente con la aparición de CPP.

General surgery and surgical specialties are essential in any healthcare system. The surgical burden worldwide has grown substantially in recent years, and estimates suggest that nearly 300 million surgical procedures are needed to address elective and emergency surgical burdens. Emergency surgery represents the largest proportion of cases, and injuries of any nature rank the highest cause of surgical need worldwide^{1,2}. Multiple trauma usually involves the abdominal or chest cavity, with a significant predilection for the former³. Moreover, abdominal pain is one of the most common reasons for consulting the emergency department (ED); furthermore, many of these patients require a surgical approach⁴. Considering the aforementioned, abdominal procedures represent the most common type of elective and emergency surgery⁵.

Despite the evolution of surgeries in the past decades and their high protocolization, postoperative complications remain a significant concern. According to available evidence, most complications are preventable⁶. Epidemiological studies support that infectious complications are the most common negative postoperative outcome, including pneumonia⁷. Although it is not the most prevalent complication, it is the one that confers the highest mortality risk and increased length of stay⁸. While pulmonary complications are infrequent compared to infectious complications after abdominal surgery, they significantly increase the patients' morbidity and cost of care. Moreover, postoperative pulmonary complications (PPC) include other elements beyond pneumonia. These conditions encompass atelectasis, pneumothorax, acute respiratory distress syndrome, pulmonary emboli, and many others⁹.

When assessed separately, PPC appear to be rare, but in ensemble, incidence rates have been reported to range between 9-40%¹⁰. Several authors have investigated clinical and laboratory variables correlated with the incidence of PPC. Understanding the risk factors can help to identify potentially high-risk patients and implement preventive measures accordingly¹¹. Previous respiratory pathology, obesity, nutritional deficits, and many other variables have been reported to increase the incidence of PPC; however, strong predictive models are lacking, and available ones require further optimization¹². This review aims to identify risk factors independently associated with the appearance of PPC.

POSTOPERATIVE PULMONARY COMPLICATIONS: WHAT WE KNEW, WHAT WE KNOW AND WHAT WE WANT TO KNOW

Following abdominal surgery, PPC are one of the most important causes of postoperative mortality, increased length of stay, admission to the intensive care unit, and healthcare costs¹³. Most surgical approaches require general anesthesia, which significantly impairs several physiological systems, including the respiratory system. After the induction of anesthesia, respiratory drive and muscle function are altered and lung volumes are reduced, and this alone explains a significant proportion of surgical complications¹⁴. The respiratory system may take up to 6 weeks to return to its preoperative state after general anesthesia for surgery¹⁵. In light of the magnitude of PPC, early identification of surgical patients at risk of these complications would allow the implementation of preventive measures to increase the survival of this population¹⁶.

Observational studies suggest that premorbid conditions play a significant role in developing PPC. For instance, Gupta et al.¹⁷ performed a retrospective analysis of the National Surgical Quality Improvement Program (NSQIP) database (2007-2008) to determine the relationship between chronic obstructive pulmonary disease (COPD) and PPC incidence. Statistical analyses reported that COPD was significantly associated with increased postoperative morbidity, mortality, and length of stay. Moreover, multivariate analyses reported that COPD was particularly associated with an increased risk of postoperative pneumonia and respiratory failure. However, for the purpose of the previous study, only patients with symptomatic severe COPD were considered.

Kim et al.¹⁸ further investigated the role of mild-to-moderate COPD concerning PPC. Nearly 400 patients with mild-to-moderate COPD were considered for this research. Multiple logistic regression analysis revealed that mild-to-moderate COPD was not a significant risk factor for PPC after abdominal surgery (odds ratio (OR) =0.79; 95% CI). Nonetheless, the retrospective aspect of the investigation and the relatively small population are significant limitations of this research. Other factors have been considered to influence the risk of PPC in COPD patients. It was reported that older age and operation time longer than five hours significantly correlate with increased risk of PPC. Similar reports have been established concerning asthma patients. Evidence suggests that a smoking index greater than 20 pack-years and Global Initiative for Asthma (GINA) severity index ≥ 3 were significantly associated with PPC in patients with asthma¹⁹.

Similarly, Fernandes et al.⁹ executed a retrospective study of inpatients submitted to urgent or elective surgery who developed PPC. Data showed that pneumonia was the most prevalent PPC in the first 48 hours after surgery. After this period, several other complica-

tions like bronchospasms, atelectasis, and pleural effusion appeared, but pneumonia remained the most prevalent. Likewise, analyses reported that preoperative abnormal arterial blood gases, higher body mass index, and patients with higher intraoperative needs for neuromuscular blocking drugs had a significantly higher risk of PPC⁹.

Likewise, Yang et al.¹¹ carried out a retrospective analysis of the NSQIP database (2005-2012) to identify predictors of PPC. Firstly, it was noted that the anatomical location of the surgery was related to the incidence of PPC. The higher the surgery, the more likely it was for the patients to develop PPC, showing the highest correlation with gastrectomy and hepatectomy. After adjusting for confounders, it was reported that older age, higher American Society of Anesthesiology (ASA) score, severe COPD, and longer operation time showed significant association with PPC incidence. On the other hand, Pessaux et al.²⁰ analyzed other variables related to the incidence of PPC within their research. Statistical analysis showed that using a nasogastric tube and intraoperative blood transfusion increased the risk of PPC. Furthermore, preoperative diabetes status was significantly associated with an increased risk of postoperative pneumonia (OR: 2.4; 95% CI: 1.3-4.5; P=0.05).

Another study by Fernandez-Bustamante et al.²¹ analyzed the incidence of PPC in noncardiac surgery. Multivariate analyses showed that emergency surgeries were more related to PPC than elective surgeries. Likewise, upper abdominal surgery showed a stronger correlation than pelvic surgery; however, the highest correlation was found with thoracic surgery, which is to be expected. The authors concluded that even mild PPC are associated with early postoperative mortality and intensive care unit (ICU) admission; therefore, increased attention and interventions are needed to improve perioperative outcomes. On the other hand, positive end-expiratory pressure (PEEP) and FiO₂ had no significant association with PPC development after adjusting for covariates in the logistic regression analysis²¹.

While age has been reported to be a factor for increased PPC, there is debate whether age itself is the problem or the higher prevalence of comorbid conditions represents a bias. In that matter, Smetana et al.²² performed a systematic review of risk factors associated with PPC. It was concluded that while unadjusted risk due to increasing age was believed to be a result of comorbid conditions inherent to aging, his analyses showed that advanced age is an important independent predictor for PPC, even after adjustment for comorbid conditions. For example, patients aged over 80 years have nearly five times more risk of developing pneumonia than those under 50 years (OR: 5.63, 95% CI: 4.62-6.84). Potential mechanisms include lack of respiratory physiological reserve, higher airway closing capacity, and lower ventilation-perfusion ratios²³.

Another factor to consider as a predictor of PPCs is the functional dependence of the patient, which is defined as the degree of help needed by the individual to fulfill routine activities. Total dependence—the inability to perform any activity alone—doubles the chances of developing postoperative pneumonia (OR: 2.066, 95% CI: 1.921-2.22)²⁴. Evidence regarding pulmonary hypertension (PH) as a risk factor for PPC is somewhat scarce. Nonetheless, Kruthiventi et al.²⁵ performed a retrospective study of PH patients that underwent noncardiac surgery. It was reported that the PPC rate was 10.2 per 100 cases, which is significantly higher than the general population. However, the study design lacked the statistical power to determine the association between PH and PPC. Another research stated that PH increased the overall risk of negative perioperative outcomes, but the only respiratory conditions addressed were respiratory failure and the need for ventilatory support²⁶.

On the other hand, good quality evidence highlights congestive heart failure as a significant risk factor for PPC. Likewise, chronic kidney disease (CKD) has also been correlated with a higher incidence of negative pulmonary outcomes²⁷. Likewise, the presence of upper respiratory tract infection one month prior to the surgery has been strongly correlated with the incidence of PPC (OR: 5.5, 95% CI: 2.6-11.5)²⁸. Another research found a low serum albumin level to be a predictor for PPC, probably because of its association with poor nutrition and chronic health compromise, both of which are associated with impaired pulmonary physiology. Similarly, low preoperative oxygen saturation, especially below 90%, was found to be strongly correlated with higher PPC risk²⁹.

Conclusions

Postoperative complications are a significant health and financial burden concerning surgical specialties. It is well known that PPC are not the most prevalent form of negative surgical outcome. However, compared to other complications, PPC significantly increase the length of stay, morbidity, and mortality. Considering the substantial impact of PPC, preventive measures are highly suggested to increase patients' survival rates. Proper risk management can significantly influence the outcomes of surgical procedures. Evidence suggests that preoperative preventive measures positively influence surgical outcomes. Nonetheless, risk factors for PPC are highly heterogeneous and difficult to fit within only one predictive model. As a result, currently available predictive models have a narrow perspective regarding this issue. Further research

is needed to adapt and optimize older predictive models, or to develop new ones. An increased pool of predictive tools would allow a more precise analysis of risk factors, in order to implement suitable measures.

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