Original Article

Postoperative respiratory complications from elective and urgent/emergency surgery performed at a university hospital

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Background: Respiratory complications have been the focus of studies aiming to identify methods of reducing postoperative morbidity/mortality and controlling the cost of treatment.

Objectives: To estimate the incidence of the respiratory complications in patients submitted to elective or urgent/emergency surgical procedures and determine any correlations between respiratory complications and potential risk factors.

Method: A retrospective cohort study of patients submitted to elective or urgent/emergency surgery at a university hospital during 2001. The sample was restricted to patients hospitalized for at least 24 hours following surgery. Data were collected from patient charts and according to protocol.

Results: Of the 5075 patients submitted to elective or urgent/emergency surgery during the year 2001, 1345 (25.5%) were included in the study. There was no statistically significant difference between elective surgery and urgent/emergency surgery in terms of respiratory complications. The incidence of respiratory complications was 11.7%. The most frequent complication (at 52.5%) was pneumonia. Overall mortality was 7.2% and 27.8% of deaths were related to respiratory complications.

Conclusion: The incidence of postoperative respiratory complications was 11.7% (11.3% in elective surgery and 12.3% in urgent/emergency surgery). Pneumonia was the most frequent complication. The risk factors that correlated with respiratory complications were previous lung disease, use of a nasogastric tube, admission to the intensive care unit, endotracheal intubation and tracheostomy.

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INTRODUCTION

Despite the pace of scientific and technological evolution, complications related to diseases and their treatments are still frequent and are the cause of great concern. In surgical treatment, postoperative complications are defined as either a second, unexpected disease that occurs within 30 days after the procedure or surgery-related exacerbation of a preexisting disease[1]. Although other complications may occur, those involving the respiratory tract are the most frequently seen and therefore make the greatest contribution to perioperative morbidity and mortality[2].

Various studies have demonstrated that, during preoperative evaluation, cardiac risk is more extensively assessed than is pulmonary risk. Upper abdominal surgery correlates more strongly with postoperative respiratory complications (PRCs) than with postoperative cardiac complications[1,3-6]. As demonstrated in a systematic review on the subject, thoracic and upper abdominal surgery are responsible for the majority of pulmonary complications. The authors estimated that diaphragm dysfunction, postoperative pain and alveolar collapse result in a 50% to 60% decrease in vital capacity and a 30% decrease in residual functional capacity[7].

Clinical observation has indicated the necessity of carefully assessing possible risk factors for complications in patients who are candidates for surgery. In a recent study, it was demonstrated that complications are determined by the combination of three factors: degree and type of contamination of the surgical site, surgical and anesthetic techniques, and patient endurance. The authors of the study concluded that 30% of nosocomial infections could be avoided[8]. However, there are distinct, conflicting results. Some studies in the literature have demonstrated that, due to conceptual differences and variability in planning, assessment and sample selection, PRC incidence might range from 10% to 81%[4]. In facilities where there is routine radiographic screening during the postoperative period, atelectasis is the most prevalent complication[1]. However, pneumonia is the major cause of mortality on surgical wards[3].

The objective of this study was to estimate the incidence of PRCs and look for correlations between PRCs and potential risk factors in patients submitted to elective or urgent/emergency surgical procedures carried out at the *Hospital Universitário da Universidade Estadual de Londrina*, which only accepts patients from the *Sistema Único de Saúde* (Public Health System) and has a surgical residency program.

METHODS

A retrospective cohort study was carried out at the *Hospital Universitário da Universidade Estadual de Londrina*. Of the 5075 patients submitted to elective or urgent/emergency surgery during the year 2001, 1345 (26.5%) met the inclusion criterion, which was restricted to patients hospitalized for at least 24 hours during the postoperative period. Patient charts were reviewed based on the monthly list of surgical procedures performed on the surgical ward, obtained from the medical records and statistics department. A standardized protocol was used for data collection. The Bioethics Committee of the *Universidade Estadual de Londrina* approved the study, in accordance with the *Conselho Nacional de Saúde* (National Health Council) Resolution 196/96.

Of the 1345 patients evaluated, 738 (54.9%) were female and 607 (45.1%) were male, and age ranged from 1 day to 96 years (median of 38 years, first and third quartiles of 24 and 75 years, respectively). A total of 124 patients (9.2%) were diagnosed with type 1 and 2 diabetes, and 75 (5.6%) were diagnosed with previous lung disease. In addition, 297 patients (22.1%) admitted being smokers, and 205 (15.2%) were diagnosed with some type of cancer. Of the patients included, 586 (44%) were submitted to urgent/emergency surgery, and 759 (56%) to elective surgery. Of these surgical procedures, 86 (6.4%) were thoracic, 526 (39.1%) were abdominal and 733 (54.5%) were performed at other sites. Surgical time ranged from 10 to 730 minutes (median of 98 minutes, first and third quartiles of 60 and 160 minutes, respectively). Duration of hospital stay prior to surgery ranged from 0 to 226 days (median of 6 days and first and third quartiles of 2 and 16 days, respectively). A total of 97 patients (7.2%) died, and 27 (27.8%) of the deaths were attributed to PRCs.

We defined PRCs as primary clinical outcomes related to diseases affecting the chest wall, pleura, pleural cavity, or lungs, including pneumonia, pulmonary thromboembolism, pulmonary empyema, lung abscess, acute respiratory insufficiency from other etiologies, and atelectasis.

Risk factors were subdivided into clinical risk factors, surgical risk factors, and clinical evolution. Clinical risk factors were gender, age bracket (1 to 11, 12 to 18, 19 to 65, and over 65), comorbidities (smoking, previous chronic lung disease, diabetes and cancer) and physical status according to the American Society of Anesthesiologists system of classification. Surgical risk factors were anesthetic technique (regional block or general), type of surgery (elective or urgent/emergency), need for a second operation, incision site (chest, abdomen or other), surgical time and use of invasive procedures (nasogastric tube or endotracheal intubation). Clinical evolution was evaluated based on length of preoperative hospitalization and whether or not the patient was admitted to the intensive care unit.

A univariate analysis using the chi-square test was used to establish correlations between risk factors and respiratory complications. We used stepwise logistic regression to measure the effect of explanatory variables on the primary outcome (PRC) and odds ratio with a 95% confidence interval to calculate its magnitude. In the process, the most significant (F test) risk factor correlations were selected for the initial model. In view of this, we verified whether the inclusion of a specific risk factor would increase the predictive ability of the model for the incidence of PRC. If the inclusion of a risk factor improved the prediction, inclusion was maintained. If not, the risk factor was rejected. Statistical significance was set at 5% ($p < 0.05$). For data analysis, we used the Statistical Package for the Social Sciences (SPSS) program, version 11.5 for Windows.

RESULTS

Of the cases analyzed ($n = 1345$), 158 (11.7%) presented one or more PRC. Of these, 91 (15%) were male and 67 (9.1%) were female. The most frequent PRC was pneumonia: 123 (52.5%) cases (Table 1). The incidence of PRC was higher in the 0-11 age bracket and over-65 age brackets (26 cases: 16.6% and 55 cases: 23.3%, respectively).

In the univariate analysis of clinical risk factors, only the incidence of tumor was statistically less than significant (Table 2). A total of 149 patients presented two or more comorbidities, and, of these, 40 (26.8%) developed a PRC. The American Society of Anesthesiologists physical status classification system was used to assess risk in 860 patients (69.9%). Of the 102 patients (11.9%) presenting PRCs, 32 (30.2%) were class 3 and 17 (60.7%) were class 4.

Among the surgical risk factors, type of surgery (elective or urgent/emergency) did not present a statistically significant difference and was excluded from the model. A total of 715 patients (53.15%) were submitted to general anesthesia, and 137 (19.2%) of those presented a PRC. Likewise, 630 patients (46.85%) were submitted to regional block anesthesia and 21 (1.3%) presented a PRC. Thoracic incision was performed in 86 patients (6.3%), 19 (22.1%) of which presented a PRC, whereas abdominal incision was performed in 526 patients (39.1%), 54 (10.3%) of which presented a PRC. A total of 200 patients (14.86%) underwent a second operation, and 64 (32%) of those presented a PRC. A nasogastric tube was used in 230 patients (17.1%), and 113 (49.1%) of those

TABLE 1

Incidence of respiratory complications in 1345 patients submitted to elective or urgent/emergency surgery (University Hospital, Londrina, Paraná)

	n	%
Pneumonia	123	52.5
Respiratory insufficiency	60	25.6
Pleural effusion	22	9.4
Pulmonary thromboembolism	13	5.5
Atelectasis	11	4.8
Empyema	03	1.3
Lung abscess	02	0.9
Total	234	100

TABLE 2

Univariate analysis of clinical risk factors correlated with postoperative respiratory complications

Variable	c^2	p
Gender	10.67	0.001
Age	46.33	< 0.001
Diabetes	4.12	0.042
Previous lung disease	136.78	< 0.001
Cancer	0.11	NS
Smoking	5.62	0.017
ASA classification	113.88	< 0.001

ASA: American Society of Anesthesiologists

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presented a PRC. A total of 240 patients (49.6%) were admitted to the intensive care unit, 147 (61.25%) of which were submitted to endotracheal intubation, and 100 (68%) of those 147 developed a PRC (Tables 3 and 4).

Risk factors presenting statistically significant correlations in the univariate analysis were selected for inclusion in the model used in the multivariate analysis. The model included the following variables: age, gender, diabetes, previous lung disease, smoking, the American Society of Anesthesiologists physical status classification, type of anesthesia, incision site, surgical time, requiring a second operation, use of a nasogastric tube, endotracheal intubation, length of preoperative hospitalization, and requiring admission to the intensive care unit. The final logistic regression model identified previous lung disease, use of nasogastric tube, requiring admission to the intensive care unit, and endotracheal intubation as predictive risk factors for the occurrence of a PRC (Table 5).

Sample distribution according to gender demonstrated that the incidence of PRCs was higher in males than in females (15% vs. 9.1%). The predominant type of PRC in males was pneumonia, with an incidence of 11.8%.

DISCUSSION

There is no convincing clinical explanation for the higher incidence of PRC in males since we cannot claim that there is a correlation between gender and PRCs[2].

Children, as well as the elderly, are more susceptible to infections. In addition to the fact that the immune systems of children are immature, the types of surgery children are generally submitted to surgery to correct congenital malformations involving multiple organs, thereby more significantly compromising the general condition of these patients. Furthermore, factors such as premature birth, low birth weight, malnutrition and respiratory diseases are the main causes of hospitalization in children under the age of 5[9]. Regarding elderly patients, it is important to consider senescence, which increases morbidity and mortality due to a reduction in the gas-exchange surface area. Consequently, there is lung elastic recoil, together with decreased respiratory

TABLE 3

Univariate analysis of surgical risk factors correlated with postoperative respiratory complications

Variable	c^2	p
Anesthetic technique	81.67	< 0.001
Type of surgery	0.21	NS
Incision site	96.73	< 0.0001
Surgical time	11.04	0.007
Second operation	90.67	< 0.001
Nasogastric tube	369.66	< 0.001
Endotracheal tube	498.15	< 0.0001

TABLE 4

Univariate analysis of clinical evolution correlated with postoperative respiratory complications

Variable	c^2	p
Length of hospitalization	81.67	< 0.001
ICU admission	398.96	< 0.0001

ICU: intensive care unit

TABLE 5

Multivariate analysis of the four main risk factors for development of postoperative respiratory complications

Risk factor	Estimate	SE	c^2	p	OR (95% CI)
Intercept	-3.78	0.209	328.5	< 0.0001	
PLD	1.97	0.374	27.9	< 0.0001	7.20 (3.46; 14.9)
NGT	1.86	0.288	42.0	< 0.0001	6.47 (3.68; 11.3)
ICU admission	1.08	0.372	8.5	< 0.0001	2.96 (1.42; 6.15)
Endotracheal intubation	1.67	0.384	18.9	< 0.0001	5.34 (2.51; 11.3)

SE: standard error; OR: Odds Ratio; 95% CI: 95% confidence interval; PLD: previous lung disease; NGT: nasogastric tube; ICU: intensive care unit

system compliance and respiratory muscle force[2]. The incidence of PRCs in the one day to 11 years age bracket and in the over-65 age bracket was 16% and 23.3%, respectively. Various studies in the literature have shown a higher risk of complications in patients over 50[1-10].

[-10].In the present study, 15.8% of the smokers presented a PRC, although there was no statistically significant difference in comparison to the other comorbidities studied. We emphasize the fact that there is an significant correlation between smoking and PRCs. Some authors believe that the relationship between smoking and PRC is indirect since respiratory symptoms are 3 to 4 times more prevalent in smokers than in nonsmokers. Therefore, smoking cessation during the preoperative period, especially for more than 8 weeks, reduces the incidence and the severity of symptoms, thereby reducing PRC incidence[1].

In our sample, only previous lung disease correlated significantly with PRCs: 41 (54.7%) of the 75 patients with previous history of lung disease had some type of PRC. The clinical characteristics of chronic lung disease patients are productive cough and progressive exercise-induced dyspnea, and the functional characteristics of such patients include partially reversible, usually progressive, obstruction. The increased sputum production is related to bacterial infections[5], which can explain the high incidence of PRCs in patients with lung disease[1,3,4,6-8,10-13,17].

A total of 149 patients (11%) presented at least two comorbidities, and 40 (26.8%) of these presented a PRC. Analyzed in isolation, these data showed a significant correlation, confirming the hypothesis that the combination of various risk factors increases the probability of PRCs[4].

The American Society of Anesthesiologists physical status classification system is the best prognostic index available for predicting mortality due to noncardiac illnesses and has been used to estimate the risk of intraoperative and postoperative complications[14]. In our study, 860 patients were classified according to the American Society of Anesthesiologists classification system, and 102 (11.9%) presented respiratory complications. Of the 485 patients who were not classified, 56 (11.5%) presented a PRC. The difference between these two groups was less than significant[10]. However, when we investigated the classification categories individually, we found a significant difference between them. Of the 106 class-3 patients (12.32% of the 860), 32 (30.06% of the 106) presented a PRC. Of the 28 class-4 patients (3.2% of the 860), 17 (60.7% of the 28) presented a PRC. These results indicate that more severe (class-4) clinical profiles increase PRC incidence.

Analysis of the anesthetic technique in relation to PRC incidence showed that the patients submitted to general anesthesia (19.2%) were more likely to present a PRC than were those submitted to regional block anesthesia[1,4,6,7,12,13,15,16]. We highlight the fact that general anesthesia is correlated with respiratory complications because it requires endotracheal intubation (which provokes muscle relaxation and the potential consequent bronchial aspiration) and mechanical ventilatory assistance (which depresses the central nervous system, reducing the cough reflex). Patients submitted to peridural anesthesia, a regional block anesthesia that does not interfere with the respiratory dynamic, presented no PRCs[12].

When we studied each type of surgery and its possible complications, a debatable issue was the possibility of significant differences between complications following elective surgery and those following urgent/emergency surgery. Some studies of PRC incidence have demonstrated that such differences exist since patients submitted to elective surgery were, from a clinical standpoint, more well prepared for the operation[1]. In the present study, our results regarding PRC incidence diverge from those of most other authors since we found no statistically significant difference between patients submitted to elective surgery and those submitted to urgent/emergency surgery.

Incisions in the upper abdomen and thorax resulted in a higher incidence of complications. This is due to the fact that using these routes of access causes diaphragmatic dysfunction and thereby reduces vital capacity by 50% to 60% and residual functional capacity by 30%. This is attributable to inhibition of the phrenic muscle reflex due to visceral manipulation, combined with postoperative pain and alveolar collapse[1,3,6,7,11,12,15,17-19]. Of the 526 patients submitted to upper abdominal surgery in the present study, 54 (10.3%) presented a PRC, and,

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of the 86 patients submitted to thoracic surgery, 19 (22.1%) presented a PRC.

It has been reported in the literature that surgical time ranging from 210 and 360 minutes increases the incidence of PRC[1,3,4,6,15]. In our study, 15.3% of the cases in which the procedure lasted over 180 minutes presented a PRC. We can conclude that longer procedures increase the risk of developing a PRC. This is due to the combination of various risk factors, such as long-term exposure to general anesthesia and its deleterious effects on respiratory function, upper abdominal or thoracic incision, invasive procedures such as the use of drains or probes, and the manual handling of patients requiring intensive care during the postoperative period.

The analysis of all surgical procedures performed demonstrated that 200 of the 1345 patients were submitted to a second operation. Although there are no data in the literature indicating that this variable is a risk factor for PRCs, our results led us to consider this possibility. We found that 32% of the patients who underwent a second operation also presented a PRC. This result is significant when we compare these patients to those (8.2%) not submitted to a second operation. When we included a second operation as a risk factor, we took into consideration the fact that patients would again be submitted to prolonged fasting prior to and after the surgery, surgical stress, anesthesia (possibly general anesthesia), immune-system depression, prolonged rest, pain, invasive procedures, and long-term hospitalization.

Length of hospitalization is a significant factor from the social and economic viewpoint and is also a condition of poor patient evolution caused by, among other factors, circulatory, respiratory or iatrogenic problems, as well as infections. We found the median length of preoperative hospitalization to be 6 days. During this period, patients can become colonized by antibiotic-resistant bacterial strains that will undoubtedly cause them to develop infections during the postoperative period. Prior hospitalization of surgical patients for more than 3 days doubles the incidence of infection at the incision site[8]. Some authors have reported that nosocomial pneumonia was considered the second most prevalent type of infection among nosocomial infections, affecting 18% of all patients undergoing surgery[10,13].

Of the 1345 studied, 158 (11.7%) presented some type of PRC. Of these, 55 (4.1%) presented at least two PRCs, and the most common combination was pneumonia and respiratory insufficiency (34.5%). Pneumonia was seen in 52.5% of the cases, proving to be the most prevalent PRC. According to data in the literature, the incidence of pneumonia in adults submitted to general surgery ranges from 18%[10,13] to 68%[17]. The incidence of pneumonia in patients over 65 submitted to general surgery has been reported to be 56%[1].

Global mortality in surgical patients ranges from 7% to 8%, and 10% to 28% of all cases of surgery-related pneumonia are fatal[1,3,4,10]. In the present study, 97 patients died, 22 (22.6%) of which had pneumonia and 11 (11.3%) of which had respiratory insufficiency.

In our final logistic regression model, we identified four risk factors that correlated with PRCs: previous lung disease, use of a nasogastric tube, admission to intensive care unit and endotracheal intubation[12]. This analysis demonstrated obvious relationships among these factors[1-3,12,13,16,17,20]. A patient diagnosed with lung disease submitted to upper abdominal or thoracic surgery would be given general anesthesia and would very likely be admitted to the intensive care unit during their postoperative period, where ventilatory support and endotracheal intubation might be used, and tracheostomy might even be performed. Since it is known that the majority of lung disease patients are undernourished, nutritional support is fundamental for these patients. Nasogastric enteral feeding is the least invasive and the most physiological method. Thus, the cycle of PRC risk factors is complete.

All risk factors mentioned in the literature were present in our univariate analysis. This led us conclude that PRCs are correlated with the general condition of patients, the type and duration of the procedure to which they were submitted, the anesthetic technique and its duration, the need for invasive procedures and intensive care. Therefore, patients in a generally debilitated state, with previous lung disease and requiring extensive surgical treatment and intensive care during the postoperative period are very likely to have a PRC.

Global PRC incidence was 11.7%. The PRC incidence in elective surgery was 11.3%, compared

to 12.3% in urgent/emergency surgery. Among the PRCs evaluated, pneumonia was the most frequent, with an incidence of 52.5%, followed by respiratory insufficiency (at 25.6%), pleural effusion (at 9.4%), pulmonary thromboembolism (at 5.5%), atelectasis (at 4.8%), pleural empyema (at 1.3%) and lung abscess (at 0.9%). Risk factors that correlated with PRC were previous lung disease, use of a nasogastric tube, admission to the intensive care unit and endotracheal intubation.

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