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Risk factor analysis of postoperative acute respiratory distress syndrome in valvular heart surgery

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ABSTRACT

Purpose: The aim of this study is to investigate the incidence, severity, and outcome of postoperative *acute respiratory distress syndrome* (ARDS), according to the Berlin definition, in isolated valvular heart surgery. The preoperative and perioperative predisposing factors of this complication were also identified.
Methods: A retrospective chart review was conducted on 457 patients who underwent isolated valvular heart surgery between January 2010 and December 2012. Clinical characteristics and outcomes were collected. The primary outcome was postoperative ARDS, according to the 2012 Berlin definition for ARDS.
Results: A total of 37 patients (8.1%) developed postoperative ARDS, with a mortality rate of 29.7%. The multivariate analysis identified that age (odds ratios [ORs], 1.067, $P \leq .001$), liver cirrhosis (OR, 7.159; $P = .001$), massive blood transfusion (OR, 2.980; $P = .005$), and tricuspid valve replacement (OR, 5.197; $P = .012$) were independent risk factors of postoperative ARDS. Furthermore, we have determined that the increased severity stages of ARDS were associated with decreased postoperative survival.
Conclusions: In conclusion, postoperative ARDS, according to Berlin definition, in valvular surgery, was associated with high in-hospital mortality. The severity of ARDS was associated with patient midterm mortality. In multivariate analysis, age, liver cirrhosis, massive blood transfusion, and tricuspid valve replacement were identified as independent risk factors of ARDS.

1. Introduction

Acute respiratory distress syndrome (ARDS) is a leading cause of postoperative hypoxemic respiratory failure and is associated with mortality rates of approximately 40% [1,2]. Cardiac surgery is a known risk factor for ARDS, which affects 0.4% to 20% of patients who underwent cardiac surgery, with a mortality even approaching 80% [3–6]. The statistical variations among the studies are depended on the different classifications and study populations. Postoperative ARDS not only contributes to increased in-hospital mortality and decreased long-term survival but also results in high medical expenditures [7,8].

The recently published 2012 Berlin definition of ARDS [9] describes ARDS as a hypoxemia that occurs within 1 week of a known clinical insult or new worsening respiratory symptoms. It is associated with bilateral opacities on chest images that cannot be fully explained by pleural effusions, atelectasis, nodules, or clinical outcomes that are not fully explained by cardiac failure or fluid overload [3]. The updated and revised Berlin definition was determined to have better mortality prediction validity and also addressed some of the limitations of the previous ARDS definition that was defined by the American-European Consensus Conference. However, there exist few literatures that have applied this new definition in their cardiac surgery population, and no previous study has ever analyzed the risk factors of ARDS after isolated valvular surgery. The aim of this study is to retrospectively investigate the incidence, severity, and outcome of ARDS in valvular surgery, as well as to identify their corresponding risk factors.

2. Materials and methods

2.1. Study design and patient population

This post hoc analysis of a prospective collected database was approved by the instructional review board of Chang Gung Memorial

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Hospital. Between January 2010 and December 2012, medical records of 506 consecutive patients, who received isolated valvular heart surgery in a tertiary referral hospital, were reviewed. All patient records were anonymized and de-identified prior to analysis. We excluded patients who received emergent operation or perioperative extracorporeal membrane oxygenation support, or those patients who died on the day of surgery. In order to appraise respiratory outcomes, patients who underwent preoperative mechanical ventilator support were also excluded. The final cohort comprised a total of 457 patients, where their detailed demographic information is listed in Fig. 1.

2.2. Data collection and definitions

Clinical characteristics and demographic data were extracted from a prospectively collected database. The primary outcome was the incidence, severity, and risk factors of postoperative ARDS. Based on the Berlin definition [9], ARDS was described as the following: (1) hypoxemia, occurring within 1 week of a known clinical insult or new or worsening respiratory symptoms; (2) chest image with bilateral opacities that cannot be fully explained by pleural effusions, atelectasis, or nodules; and (3) clinical outcomes that are not fully explained by cardiac failure or fluid overload. Also, ARDS is divided into 3 categories that included the following: (1) mild ARDS (200 mm Hg < Pao_2/FiO_2 ≤300 mm Hg with PEEP [positive end-expiratory pressure] or continuous positive airway pressure ≥5 cm H_2O), (2) moderate ARDS (100 mm Hg < Pao_2/FiO_2 ≤200 mm Hg with PEEP ≥5 cm H_2O), and (3) severe ARDS (Pao_2/FiO_2 ≤100 mm Hg with PEEP ≥5 cm H_2O). Patient diagnoses were independently confirmed by 2 physicians with who have reviewed the medical records.

2.3. Statistical analysis

Continuous variables were summarized by mean and SE unless otherwise stated. The primary end point was the comparison of postoperative outcome between ARDS and non-ARDS groups. Kolmogorov-Smirnov test was used to determine the normal distribution of each variable. Student *t* test was used to compare the means of continuous variables and normally distributed data; otherwise, Mann-Whitney *U* test was used. Categorical data were tested using the χ^2 test or Fisher exact test. Furthermore, risk factors of ARDS were assessed using univariate analysis. Variables that were statistically significant in the univariate analysis were included in the multivariate analysis with logistic regression. Discrimination was assessed using the area under a receiver operating characteristic curve (AUROC), which was compared with a nonparametric approach. Categorical data were tested by χ^2 test. *P* value less than .05 was considered statistically significant.

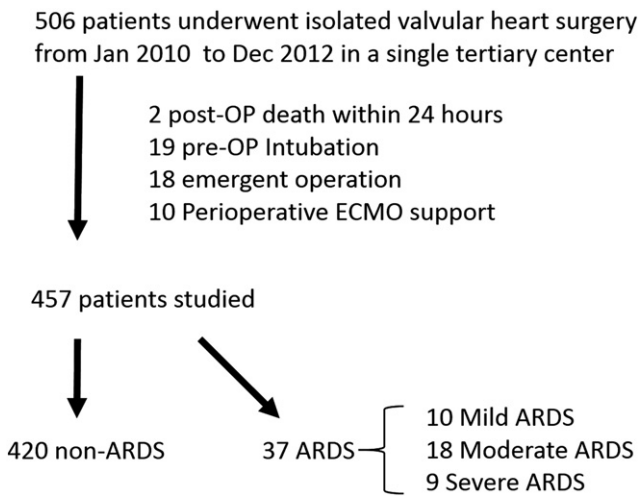

Fig. 1. Study design. ECMO indicates extracorporeal membrane oxygenation.

3. Results

3.1. Characteristics of the study population: ARDS vs non-ARDS group

A total of 457 adult patients, with a mean age of 58.0 ± 0.7 years and 48.6% (235 men and 222 women) female, were investigated in this study. A total of 37 (8.1%) patients developed postoperative ARDS (10 [27.0%] mild, 18 [48.6%] moderate, and 9 [24.3%] severe) in our cohort. All patient characteristic are listed in Table 1. Compared with non-ARDS patients, the ARDS group is older and have more diabetes mellitus, more congestive heart failure (CHF) functional class (Fc) III/IV, more liver cirrhosis, and higher preoperative risk score. The mean values of EuroSCORE and Society of Thoracic Surgeons score on mortality risk were 6.6% ± 0.4% and 4.9% ± 0.4% for the ARDS and non-ARDS group, respectively. The observed in-hospital mortality rate of this study was 5.0%.

Aortic valve replacement was performed in 163 (36.8%) patients. The mitral procedures such as mitral valve repair and replacement were performed in 195 (42.7%) and 112 (24.5%) patients, respectively. Tricuspid valve repair was also performed in 151 (33%) patients. The mean cardiopulmonary bypass and aortic clamping time were 160 ± 3.0 and 109.3 ± 2.1 minutes, respectively. The detailed surgical information and perioperative data are listed in Table 2. Operative characteristics, including the type of surgery performed, type of valve replacement, concomitant procedures, duration of cardiopulmonary bypass time, and aortic cross-clamping time, were similar between the 2 groups. However, the ARDS group had more cases of tricuspid valve replacement and tissue valve tricuspid replacement. Compared with the non-ARDS group, the ARDS group had more patients who had massive blood transfusions (18.3% and 4.9%; ARDS vs non-ARDS, $P < .001$), defined by the transfusion of more than 4 units of packed red blood cells (PRBCs). Furthermore, the scoring system results, determined when patients were admitted into the intensive care unit (ICU), which included Acute Physiology, Age and Chronic Health Evaluation III (APACHE III) and the Sequential Organ Failure Assessment (SOFA), were significantly higher in the ARDS group than in the non-ARDS group (all $P < .001$).

3.2. Postoperative outcomes

There were 23 (5.0%) in-hospital mortalities, where the ARDS group had higher in-hospital mortality than did the non-ARDS group (29.7% and 2.9%; ARDS vs non-ARDS, $P < .001$). Postoperative morbidity analysis showed that when compared with the non-ARDS group, the ARDS group had more patients who underwent tracheostomy (16.2% and 0.5%; ARDS vs non-ARDS, $P < .001$), more acute renal failures (24.3% and 1.2%; ARDS vs non-ARDS, $P < .001$), and more postoperative cerebral vascular accidents (13.5% and 1.2%; ARDS vs non-ARDS, $P = .045$). Furthermore, the patients in the ARDS group also had longer ventilator time, ICU, and hospital stay durations. The detailed comparison of the different postoperative outcomes is listed in Table 3. In the subsequent analysis, where the patients ARDS severities were classified according to the Berlin definition, 24%, 49%, and 27% of the patients met the criteria of mild, moderate, and severe stages of ARDS, respectively. The mortality rate was determined to correspond with increased severity stages of ARDS from mild (11%), moderate (27.8%), to severe (50%).

3.3. Logistic regression analysis for ARDS according to preoperative and perioperative variables

The logistic regression model was applied to the ARDS patients according to the preoperative and perioperative factors. Although age, liver cirrhosis, CHF Fc III/IV, diabetes mellitus, tricuspid valve replacement, and blood transfusion greater than 4 units were associated with