PREVALENCE OF ACUTE RESPIRATORY DISTRESS SYNDROME AFTER CARDIAC SURGERY

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Acute ("adult") respiratory distress syndrome (ARDS) is an extreme form of acute lung injury that is characterized by inflammation of the lung parenchyma and by increased microvascular permeability. ARDS carries an overall mortality of more than 50%.¹ Cardiopulmonary bypass (CPB) can cause a systemic inflammatory response and is regarded as a causative factor for the development of ARDS.¹ Since the potential association between cardiac surgery and ARDS was first described, very few investigators have attempted to assess the prevalence of ARDS after CPB by using widely accepted clinical criteria.¹⁻³ In these studies the prevalence varied from 1.0% to 1.7%, with a mortality rate of 50% to 68%, in patients who were operated on between 1980 and 1993. This study aims to assess the prevalence and mortality of ARDS in a large patient population that underwent a variety of cardiac surgical procedures to test the hypothesis that, in recent years, ARDS occurs infrequently after cardiac surgery.

Methods. Between January 1993 and July 1997, 2464 patients underwent cardiac surgery with CPB at the Hammersmith Hospital, London, and had their clinical data put into a prospective computerized database. For this study, information was extracted from the database and analyzed. In addition, the clinical notes of all patients who were reported to have ARDS or postoperative renal failure or who required assisted ventilation for more than 72 hours were reviewed retrospectively. Patients were excluded when clinical and case history data suggested the presence of cardiogenic pulmonary edema or primary lung infection. Diagnosis of ARDS was based on the criteria of "an expanded definition of the ARDS" proposed by Murray and coworkers.⁴ The Murray scoring system includes 4 criteria for the development of acute lung injury: a "scoring" of hypoxemia, a "scoring" of respiratory system compliance, chest radiographic findings, and level of positive end-expiratory pressure. Each criterion receives a score from 0 to 4 according to the severity of the condition. The final score is obtained by dividing the collective score by the number of components that were used. A final score of more than 2.5 indicates the presence of ARDS.

Nominal data were analyzed by means of the χ^2 test and interval data by means of the Mann-Whitney test for univariate analysis. Logistic regression was used for multivariate analysis.

Results. ARDS occurred in 12 (0.5%) of the 2464 patients included in the study. Characteristics of the 12 patients are shown in Table I. Eleven (91.6%) of the 12 patients died; in all of them ARDS was part of multiple organ failure. The mean time between the operation and death was 12.4 days (range, 4-35 days). The single survivor had isolated ARDS with no other organ failure. Sepsis and at least 1 episode of severe hypotension occurred in all 12 cases. Statistical analysis showed that poor preoperative left ventricular function (ejection fraction < 0.3), dyspnea New York Heart Association (NYHA) classes III and IV, and emergency operation (χ^2 test), but not the duration of CPB (Mann-Whitney), were univariably associated with the development of ARDS (Table II). Multivariate analysis confirmed that poor left ventricular function ($P = .02$) and dyspnea NYHA classes III and IV ($P = .03$) were variables significantly related to the development of ARDS, whereas emergency operation failed narrowly to reach statistical significance ($P = .054$).

Discussion. This study measured the prevalence of ARDS in a population of 2464 patients who underwent cardiac surgery at the Hammersmith Hospital, London, in the mid-1990s. Although the prevalence of the condition at the same hospital in previous years is unknown, we aimed to test the hypothesis that ARDS occurs infrequently after cardiac surgery in recent years, by comparing our results with those of previous studies from other centers. Consequently, we chose the Murray criteria for our study because these were used in 2 of the 3 previous relevant publications,^{2,3} making a comparative study more valid.

Prevalence of ARDS in the study was 0.5%, compared with 1% to 1.7% reported in previous articles.¹⁻³ In contrast, the mortality rate of the condition was 91.6%, which is significantly higher than reported before. It is worth noting that the 11 deaths followed ARDS with multiple organ failure, whereas the only survivor had an isolated lung injury. ARDS as part of multiple organ failure is known to carry, as expected, a significantly higher mortality than ARDS with only one or two other failing major organs.³ This study suggests that the latter condition has become infrequent in recent years, resulting in a decrease of the overall prevalence of ARDS after CPB. The mortality of multiple organ failure, however, remains extremely high. A recent study from Switzerland reports similarly high mortality in patients with ARDS as part of multiorgan failure after CPB.³ This change in the profile of the extreme form of respiratory failure after cardiac surgery may be due to improved primary postoperative care and ventilation.

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Table I. ARDS after cardiac surgery: Summary of patients' data

Pt. No. (age, sex)	Angina	Dyspnea	Prev. MI	EF	Priority	Operation	CPB time (min)	Complications	Day of death
1 (76, M)	III	II	2	P	Elective	CABG and AAA	72	SVT, renal failure, sepsis	35
2 (46, M)	IV	III	No	F	Urgent	Third AVR	123	Sepsis	4
3 (49, M)	III	III	2	P	Urgent	CABG	138	LVF, renal failure, sepsis	7
4 (59, M)	II	III	No	G	Elective	CABG	123	VF arrest, pancreatitis, sepsis	7
5 (75, M)	IV	III	1	P	Urgent	CABG	109	LVF, renal failure, sepsis	9
6 (65, F)	III	Asymptomatic	1	G	Urgent	CABG	51	LVF, renal failure, sepsis	20
7 (71, M)	III	II	4	P	Urgent	CABG	82	Acute MI, sepsis	6
8 (63, M)	IV	IV	No	P	Emergency	MVR	51	LVF preop, sepsis	Survived
9 (71, M)	III	III	1	P	Emergency	CABG	61	LVF, renal failure, sepsis	16
10 (67, M)	Asymptomatic	Asymptomatic	No	P	Emergency	MVR, endocarditis	130	Hepatic failure, LVF, sepsis	15
11 (67, M)	I	I	No	G	Elective	CABG	83	AF, LVF, sepsis	10
12 (64, M)	II	III	3	P	Elective	CABG	71	AF, perforated DU, sepsis	8

AAA, Abdominal aortic aneurysm repair; AF, atrial fibrillation; AVR, aortic valve replacement; CPB, cardiopulmonary bypass; DU, duodenal ulcer; EF, ejection fraction ($P < 30\%$; $F 30\%-60\%$; $G > 60\%$); LVF, left ventricular failure; MI, myocardial infarction; MVR, mitral valve replacement; SVT, supraventricular tachycardia; VF, ventricular fibrillation.

Although, by definition, ARDS is not primarily due to cardiac failure, conditions that indicate the presence of poor cardiac function preceded its development among the patients of this study. Statistical analysis identified poor left ventricular function, high dyspnea class, and emergency operation as significant risk factors for the development of ARDS after CPB. The exact pathophysiologic mechanisms for the development of ARDS are still not fully understood. Sepsis and episodes of hypotension preceded ARDS in all patients of this study and have also been associated with the condition in previous articles.¹ These findings indicate that CPB may be an exacerbating factor but is certainly not solely responsible for the development of acute severe lung injury after cardiac surgery.

In view of our improving understanding of the humoral and cellular mechanisms that take place during the inflammatory response,⁵ it is hoped that new preventive and therapeutic strategies will emerge, resulting in more effective treatment of conditions such as acute lung injury and ARDS. ARDS appears to occur infrequently in cardiac surgery, but its catastrophic results justify our attention.

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Table II. ARDS after cardiac surgery: Univariate analysis using all patients who did not have ARDS as a control group

Patients' characteristics	ARDS (n = 12)	All other patients (n = 2452)	P value
Mortality	11 (91.6%)	107 (4.4%)	<.001
Mean age (y)	64 ± 9	64 ± 10	.2
Sex			
Male	11 (92%)	1984 (81%)	.3
Female	1 (8%)	468 (19%)	
Preoperative risk factors			
Hypercholesterolemia	5 (42%)	784 (32%)	.5
Diabetes mellitus	1 (8%)	392 (16%)	.5
Smoking	9 (75%)	1500 (61%)	.3
Previous MI	7 (58%)	913 (37%)	.13
COPD or asthma	3 (25%)	529 (22%)	.8
Preoperative characteristics			
Ejection fraction <0.3	8 (67%)	263 (11%)	<.001
Angina class III or IV	7 (58%)	883 (36%)	.10
Dyspnea class III or IV	7 (58%)	599 (24%)	.006
Operative characteristics			
Emergency operation	3 (25%)	110 (5%)	<.001
Urgent operation	5 (42%)	619 (25%)	.19
CPB time (min)	91 ± 31	81 ± 24	.6
Cross-clamp time (min)	45 ± 15	49 ± 24	.9

COPD, Chronic obstructive pulmonary disease; CPB, cardiopulmonary bypass.

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