

Contents

Title	Page
♦ List of Abbreviations	II
♦ List of Figures	V
♦ List of Tables	VI
♦ Introduction	1
♦ Aim of the Work	4
♦ CHAPTERS	
▪ Phsiology of respiration.....	5
▪ Pathogenesis of Pulmonary Dysfunction After Cardiac Surgery	38
▪ Intraopreative Protective Lung Strategy	55
▪ Postoperative Protective Lung Strategy.....	80
♦ Summary	108
♦ References	110
♦ Arabic Summary	—

List of Abbreviations

AA	: Arachidonic Acid
ABG	:Arterial Blood Gases
ACP	: American College of Physicians
AP	: Activating Protein
ARDS	: Adult Respiratory Distress Syndrome
ARM	:Alveolar Recruitment Manuver
ASA	: American Society of Anesthesiologists
BH4	: Tetrahydrobiopterin
BAL	:Bronchoalveolar Lavage
C	:Complement
CABG	: Coronary Artery Bypass Graft
CD	:Cluster Of Difference
cGMP	: Cyclicguanosinemonophosphate
CNO	:ConstitutiveNO
CO	: Carbonmonooxide
COPD	: Chronic Obstructive Pulmonary Disease
CPB	: Cardio-Pulmonary Bypass
CPET	:Cardiopulmonary Exercise Test
CRI	:Complement Receptor 1
CR	: Complement Receptor
DHCA	:Deep Hypothermic Circulatory Arrest

DLCO	:Diffusion Capacity Of CO ₂
EC	: Endothelial Cell
ECC	: Extra-Corporeal Circulation
eNOS	: Endothelial Nitric Oxide
ERV	: Expiratory reserve volume
ETCO₂	:End Tidal CO ₂
f	: Breathing Frequency
FEF	: Forced expiratory flow
FEV	: Forced expiratory volume
FRC	: Functional Residual Capacity
FRC	: Functional residual capacity
FVC	: Forced vital capacity
HUVEC	: Human Umbilical Vein-Derived EC
IC	: Inspiratory capacity
ICAM	: Intercellular Adhesion Molecule
ICU	: Intensive Care Unit
IKB	:Inhibitor of KB
IL	:Interleukins
IM	: Intra-Muscular
IMT	: Preoperative Intensive Inspiratory Muscle
INO	:INO derived NO
INOS	:Nitric Oxide Synthase
IRV	: Inspiratory reserve volume

IV	: Intra-Venous
LED	:Light Emitting Diode
LPS	: Lipopolysaccharide
MEP	:Maximum Expiratory Pressure
MIP	:Maximum Inspiratory Pressure
MUF	: Modified Ultrafiltration
NF-KB	: Nuclear Factor kb
NO	: Nitric Oxide
NOS	: Nitric Oxide Synthase
NSAID	: Non Steroidal Anti Inflammatory Drugs
NSQIP	: National Surgical Quality Improvement Program
OKT3	:Muromonab CD3
P_a	: Pulmonary Arterial Pressure
PA	: Alveolar Pressure
PAH	:Pulmonary Artery Hypertension
PaCO₂	: Partial Pressure of CO ₂
PaO₂	: Oxygen Partial Pressure
PAF	: Platelet-Activating Factor
P_{alv}	: Alveolar Pressure
PCA	: Patient Controlled Analgesia
PECAM	: Platelet-Endothelial Cell Adhesion Molecule
PEEP	: Positive End Expiratory Pressure
PEP	: Positive Expiratory Pressure

PEF	: Peak expiratory flow
PEFR	:Peak Expiratory Flow Rate
PFTs	: Pulmonary Function Tests
PLA2	: Phospholipases A2
PMN	:Polymorphnuclear Leucocytes
PPC	: Postoperative Pulmonary Complications
P_{pl}	: Pleural Pressure
P_v	: Pulmonary Venous Pressure
Q	:Flow
RV	: Residual volume
ROS	:Reactive Oxygen Species
TENS	: Transcutaneous electrical nerve stimulation
TH	:T- Helper Cell
TLC	: Total lung capacity
TNF	: Tumor Necrosis Factor
t-PA	:Tissue Plasminogen Activator
V'A	: Alveolar Ventilation
V_A/Q	:ventilation perfusion ratio
V'CO₂	:CO ₂ Production
VO₂	:Oxygen Consumption
VC	: Vital capacity
VCAM	: Vascular Cell Adhesion Molecule

V_{CO_2} : Body's Rate Of CO₂ Production
 V_D : Dead space
 V_E : Minute Ventilation
 V_t : Tidal volume

List of Figures

Fig. No.	Title	Page No.
1-1	Pressures on both sides of the chest wall.	6
1-2	Relationship between lung volume and transpulmonary pressure.	8
1-3	Lung zones.	10
1-4	Gravity effect on blood flow and ventilation in the alveoli.	15
1-5	Ventilation/perfusion ratios affect capillary blood gas tension.	17
1-6	Ventilation-perfusion ratios within single alveolar-capillary unit.	19
1-7	Alveolar gas composition at different ventilation-perfusion ratios.	22
1-8	Shunts and venous admixture.	25
1-9	Spirometry measures lung volume.	31
2-1	Schematic of the inflammatory process induced by CPB.	43
2-2	Pathways leading to the activation of NF- κ B& the production of adhesion molecules.	49
2-3	EC, platelets and leukocytes interaction.	52
4-1	Weaning protocol.	96

List of Tables

Table No.	Title	Page No.
1	Lung volumes	26
2	Risk factors for postoperative pulmonary complications.	84
3	An updated index for respiratory failure.	86

Protective Lung Strategies during Cardiopulmonary Bypass

Essay

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استراتيجيات حماية الرئة خلال استخدام ماكينة القلب الاصطناعية

رسالة

توطئة للحصول على درجة الماجستير فى التخدير مقدمة من

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بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

قالوا

سببنا انك لا تعلم لنا
إلا ما علمتنا إنك أنت
العليم العظيم

صدق الله العظيم

سورة البقرة الآية: ٣٢

Introduction

Postoperative cardiopulmonary bypass (CPB)-induced lung dysfunction remains a serious complication that could lead to life-threatening problems. CPB is associated with a whole-body inflammatory response. The contact of blood components with the artificial surface of the bypass circuit causes activation of complements, upregulation of cytokines and adhesion molecules and induction of oxygen-free radicals. The pathogenic consequences are adhesions of complement-activated neutrophils to endothelial cells, neutrophil migration into the extravascular spaces, and free-radical mediated pulmonary damage. Injured endothelial cells are vulnerable to the cytokine-mediated inflammatory cascade. Moreover, CPB renders the lung being at risk for ischemic insults because lung perfusion is maintained solely by the bronchial arterial system **(Suzuki, 2010)**.

Post ischemic reperfusion of the lung up regulates adhesion molecules and enhances neutrophil-endothelial cell adhesion and extravascular neutrophil sequestration, thereby aggravating further structural and functional abnormalities of pulmonary endothelial cells. Thus the systemic inflammatory response and ischemia-

reperfusion during CPB constitute a vicious network in the pathogenesis of CPB-derived lung injury (**Suzuki, 2010**).

Patients without pre-existing lung conditions can develop a wide array of pathologies ranging from diminished functional residual capacity (FRC) to acute lung injury (which may progress to adult respiratory distress syndrome {ARDS} in 12% of cardiac surgical patients). Those with preoperative lung impairment may have similar, but exaggerated effects. An estimated 8% of patients can experience prolonged postoperative mechanical ventilation and 7% required reintubation (**Siepe et al., 2008**).

By avoiding CPB, reducing its time or by minimizing the extracorporeal surface area with the use of miniaturized circuits of CPB beneficial effects on lung function are reported (**Massoudy et al., 2003**).

In addition, replacement of circuit surface with biocompatible surfaces like heparin-coated a better postoperative lung function is observed (**De Vroege et al., 2004**).

Meticulous myocardial protection by using hypothermia and cardioplegia methods during ischemia and reperfusion remain one of the maintenance of postoperative lung function. The partial restoration of

pulmonary artery perfusion during CPB possibly contributes to prevent pulmonary ischemia and lung dysfunction. Using medication such as corticosteroids and aprotinin, which protect the lungs during CPB and leukocyte depletion filters for operations expected to exceed 90 minutes in CPB-time appear to be protective against the toxic impact of CPB in the lungs (**Warren et al., 2007**). The newer methods of ultrafiltration used to scavenge pro-inflammatory factors seem to be protective for the lung function (**Huang et al., 2003**). In a similar way, reducing the use of cardiotomy suction device it is expected that the postoperative lung function will be improved (**Philippou et al., 2000**).