

Near Misses in Cardiac Surgery

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Editors

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Second Edition

 Springer

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With affection and respect to the memory of Philip N. Sawyer, MD, who initiated me into the rites, to the memory of David Preston Boyd, MD, who illuminated my path, and to Allison Elizabeth, Evan Preston, and Ladybug, who give relevance to everything that is good and worth a struggle.

Myles E. Lee

And to the patients who place their lives in our hands, the trainees who accept the challenge of the specialty, to our colleagues who support us as a team, and to the less visible members of the team, our families, who unselfishly make the sacrifices necessary to support us through the lows associated with our “near misses” and even harder through our “hits.”

Thoralf M. Sundt and Duke E. Cameron

Foreword

A contemporary medical novelist, who is also a physician, once asked me if anything ever happened in the operating room that instantly changed the environment from quiet solitude to a life-threatening crisis. Experienced cardiac surgeons will surely smile at that question. The example that I provided to my novelist friend was acute aortic dissection during cannulation for cardiopulmonary bypass. Such an event demonstrates that the exhortation, “The best way to treat complications is to avoid them,” is not always possible.

Since the advent of open-heart surgery some 70 years ago, the need to respond immediately and effectively to such life-threatening events has resulted in the perplexing tendency to describe surgeons, especially cardiac surgeons, as being courageous. However, a popular modern philosopher, G. K. Chesterton (1874–1936), defined courage as “.... a strong desire to live taking the form of a readiness to die.” While cardiac surgeons routinely face the responsibility of treating patients who clearly desire to live but risk the real possibility of dying, the surgeon is at no imminent risk of death. Thus, it seems more appropriate to speak of “courageous patients” than of “courageous surgeons.” Nevertheless, more than any other practitioners of medicine, cardiac surgeons can too often converse normally with a patient in the morning and pronounce that patient dead on the same afternoon. Since the only intervening event in such instances is the surgical procedure, cardiac surgeons have a moral responsibility to exert maximum effort at developing their skills. Obviously, those skills include manual dexterity but perhaps more importantly, they also include the ability to avoid problems and to deal with them quickly and efficiently when they occur. Mistakes, “near misses,” are often more instructive than event-free successes, but the latter are usually forgotten. However, “near misses” are never forgotten.

These simple, rather banal, truths explain why the first edition of “Near Misses in Cardiac Surgery” by Dr. Myles Lee, first published nearly 30 years ago, quickly became a must-read for a generation of cardiac surgeons. Myles Lee is a superb cardiac surgeon with all the gifts of manual dexterity, knowledge of his subject, and the ability to convey that knowledge to his peers. The art of teaching is simply the ability to transfer the information in the teacher’s mind to the mind of the student.

There are multiple techniques for accomplishing that task and the approach utilized by Dr. Lee in “Near Misses in Cardiac Surgery” has proven to be highly effective. An actual clinical case of a surviving patient is presented, and the patient’s problem is posed to the reader, who is faced with determining the cause of the problem and solving it before the patient’s demise. After giving the reader this opportunity, the clinical problem is then identified, and its actual resolution is revealed. Each case presentation concludes with a detailed discussion and references. Thus, the reader is challenged to act as if the fate of each patient depends on his or her ability to make appropriate decisions quickly and under pressure before tragedy strikes, a familiar real-world situation for all cardiac surgeons.

“Near Misses in Cardiac Surgery” was first published in 1992, and an edition was reissued in 2009. It is now being updated under the guidance of new co-editors, Dr. Thoralf M. Sundt III and Dr. Duke E. Cameron, two of the most respected and admired cardiac surgeons in our profession. Dr. Sundt is Churchill Professor of Surgery at Harvard and Chief of the Division of Cardiac Surgery at the Massachusetts General Hospital in Boston. Dr. Cameron, Former Professor and Chief of Cardiac Surgery at Johns Hopkins University in Baltimore, is currently a colleague of Dr. Sundt’s as Professor of Surgery at Harvard, Co-Director of the Thoracic Aortic Center at Massachusetts General Hospital. Both new editors are Past-Presidents of the American Association for Thoracic Surgery, a testament to the esteem in which they are held by their peers. This second edition of “Near Misses in Cardiac Surgery” is more than worthy of the high standard set by the first edition. It includes multiple new clinical cases and of course updated modern solutions and references to the problems posed. This new edition is once again a must-read for all professionals who are involved or interested in modern cardiac surgery.

Chicago, Illinois, USA
October 2021

James L. Cox, MD

Preface

With its emphasis on teamwork, interdisciplinary communication, anticipation of next steps, standardization and simplicity of techniques, and unflagging vigilance for the unexpected, *Near Misses in Cardiac Surgery*, in print since 1992, created a real-time atmosphere in which a nonjudgmental approach to problem-solving in adverse circumstances, often with incomplete information, facilitated the conversion of experience into corrective action. Written in the second-person present tense, and knowing in advance that all the patients survived, the reader, as surgeon, experienced the terror and anguish of confronting unexpected difficulties that if not immediately corrected would have resulted in the patient's demise.

Advances in surgical techniques, such as off-pump procedures, mini-invasive incisions, and robotic surgery, as well as catheter-based methods to replace valves, close inter-chamber septal defects, and repair aortic aneurysms performed by interventionalists in hybrid operating rooms, have only heightened the need to recognize teamwork and communication, anticipation, standardization, and vigilance.

My goal, to paraphrase Kipling, was to enable readers to keep their heads "when all about you are losing theirs and blaming it on you." I learned on my first day in medical school that "you are responsible for the skin and its contents." That is when I decided to become an internist who operates. This approach lent credence to my belief that decisions, based upon the ability to apply accumulated knowledge, are more important than incisions. The surgical and non-surgical lessons internalized from each patient interaction provide the confidence that enables us to make the best decisions and function in stressful situations while transferring equanimity to others in the operating room. I must confess it was more enjoyable to write about these experiences than to live through them (it is not only the patient who goes home with scars!). Clearly, surgeons do not play God. God does not sweat the way we do.

Our patients exhibit great courage and trust as they face the unknown, often at the mercy of strangers. As Theodore Roosevelt said, "no one cares how much you know until they know how much you care." Our obligation is to assure them of the

safest passage through uncharted waters. In this sense, we must never follow our patients. We must lead them.

Inglewood, USA

Myles E. Lee

During recent years, as Duke Cameron and I have had the good fortune to work in the same unit, we have found more and more things in common, one of which is our high regard for Dr. Lee's original text. We have found it a remarkably useful tool educating ourselves and our residents, filling a niche not quite satisfied by the standard texts in our specialty. The book was engaging both for the literary style in which Dr. Lee described the cases and the practical relevance of each scenario. It was, in fact, following a near miss in our practice that we looked at one another and remarked how useful it would be to our trainees if *near misses* were updated to reflect contemporary practice. We were delighted when Dr. Lee was receptive and so began a delightful journey to create a second edition making every effort to preserve the attributes of brevity, relevance, and honesty that characterize the original work.

It is our earnest hope that readers will find this version as engaging and useful as we found the original. Cardiac surgery is a complex endeavor in which accidents are, at some level, inevitable as it is the case for other such industries. A great deal has been written about error prevention with tools such as checklists, but a more comprehensive approach to error management as has been adopted by other high-risk, high-consequence industries must include error capture and recovery. This book focuses on error capture through vigilance and error recovery through teamwork, a territory less crowded in our literature. We have all made mistakes in our clinical practices. Meaning can be derived from those errors—and their consequences—if we learn from them ourselves and share those learnings with others.

Boston, USA

Thoralf M. Sundt
Duke E. Cameron

Acknowledgements

When Dr. Sundt and Dr. Cameron approached me with their proposal to not only update *Near Misses in Cardiac Surgery* but to add numerous cases from their own voluminous archives, I was relieved to learn I had not been alone all these years. I feel honored to share the arena with surgeons of their stature who saw fit to pick up where I left off. I wish to acknowledge all my past colleagues, men and women of erudition, skill, courage, tenacity, and indefatigability, upon whose shoulders I have stood and from whom I learned everything.

Dr. Lee

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Acronyms

ACT	Activated clotting time
ARDS	Acute respiratory distress syndrome
AS	Aortic stenosis
ASA score	American Society of Anesthesiologists Physical Status Score
AV	Atrio-ventricular groove dissociation
AVM	Arteriovenous malformation
AVR	Aortic valve replacement
BMI	Body mass index
BSA	Body surface area
CABG x3	Three-vessel coronary artery bypass graft operation
CCU	Cardiac care unit
CO	Cardiac output
COPD	Chronic obstructive pulmonary disease
CT	Computed tomography
CTA	Computed tomographic angiogram
CTEPH	Chronic thromboembolic pulmonary hypertension
CVP	Central venous pressure
CXR	Chest X-ray
DVT	Deep venous thrombosis
eCPR	Extracorporeal cardiopulmonary resuscitation
ED/ER	Emergency department/emergency room
EKG	Echocardiogram
EOPA(r)	Elongated One-Piece Arterial Cannula
Esmark	Esmark dressing; Esmark with Ioban dressing
HCT	Hematocrit
Heyde syndrome	Multisystem disorder: aortic stenosis, gastrointestinal bleeding; acquired von Willebrand syndrome
HIT/HITT	Heparin-induced thrombocytopenia (HIT) and thrombosis (HITT)
HOCM	Hypertrophic obstructive cardiomyopathy
IABP	Intra-aortic balloon pump

ICD	Implantable cardioverter-defibrillator
ICU	Intensive care unit
IMA	Internal mammary artery
INR	International normalized ratio (PTT/INR)
ITA	Internal thoracic artery
IVC	Inferior vena cava
IVUS	Intravascular ultrasound
LAD	Left anterior descending
LAO	Left anterior oblique
LIMA	Left internal mammary artery
LITA	Left internal thoracic artery
LVAD	Left ventricular assist device
MAC	Mitral annular calcification
MAP	Mean arterial pressure
MVO2	Myocardial oxygen consumption
MVR	Mitral valve replacement
NT-proBNP	N-terminal (NT-pro hormone BNP
OHT	Orthotopic heart transplant
OM	Obtuse marginal artery
OM1	Ostial lesion
OM2	Ostial lesion
P1, P2	Scallop
PA	Physician assistant
PA	Pulmonary artery
PAPi	Pulmonary arterial pulsatility index
PCI	Percutaneous coronary intervention
PCWP	Pulmonary capillary wedge pressure
PDA	Posterior descending artery
PEA	Pulseless electrical activity
PEEP	Positive end expiratory pressure
PFO	Patent foramen ovale
PPM	Permanent pacemaker
PTT	Prothrombin time
PVR	Pulmonary vascular resistance
PVR	Pulse volume recording, i.e., blood pressure cuffs
RAO	Right anterior oblique, e.g., cranial projection
RCA	Right coronary artery
RFV	Right femoral vein
RIJ	Right internal jugular
ROSC	Return of spontaneous circulation
RV	Right ventricle
SA	Sinoatrial node
SAM	Systolic anterior motion
SBP	Systolic blood pressure
SH needle	Stands for small half circle needle

SMA	Superior mesenteric artery
STEMI	ST elevated myocardial infarction
SVC	Superior vena cava
SVG	Saphenous vein graft
TACO	Transfusion-associated circulatory overload
TEE	Transesophageal echocardiogram
TEVAR	Thoracic endovascular aortic repair
TRALI	Transfusion-associated lung injury
VA-ECMO	Veno-arterial extracorporeal membrane oxygenation
VV-ECMO	Veno-venous extracorporeal membrane oxygenation

Chapter 1

Aortic Cannulation



Jordan P. Bloom, Myles E. Lee, and Arminder S. Jassar

Problem

The sun's golden crest is just visible over the mountain tops as you bound out of bed and head for the hospital on an empty freeway enchanted by a Chopin nocturne. You will operate on a 45-year-old man with an 8-year history of exertional angina. He had exercise-induced anterior segment wall motion abnormalities, a positive exercise thallium study, and angiographic confirmation of a long muscle bridge overlying the midportion of the left anterior descending coronary artery. Except for some ventricular apical akinesis, cardiac function is normal. Medical therapy, which included beta-blockers and calcium channel blockers, had failed to relieve the symptoms. Dividing a muscle bridge? A resident's case!

At surgery, the aorta was slightly smaller than expected for a 75 kg patient. Nonetheless, you palpate the aorta to identify a soft spot and perform your standard aortic cannulation using a 20 Fr EOPA arterial cannula at the level of the pericardial reflection. You observe normal pulsatile back bleeding through the aortic cannula upon de-airing, and the line pressure correlates with the radial arterial pressure. The right atrium was cannulated using a 29/37 Fr dual stage venous cannula and an aortic root vent/cardioplegia cannula was placed uneventfully. After performing the pre-bypass checklist, cardiopulmonary bypass is commenced. The drainage appears adequate, and you ask the perfusionist to drift to 34 °C for an anticipated short case.

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As you elevate the heart from the pericardium to identify the LAD, the perfusionist casually informs you that she cannot maintain a flow rate of more than 1.8 L/min/m^2 due to high arterial inflow pressure despite a right radial arterial line pressure of only 34 mmHg. You let the heart down back into the pericardial space. You do your best to inspect the aorta. True, there was a subadventitial hematoma at the cannulation site as sometimes happens, but now it seems more extensive. You tell yourself you have seen this before without complications, but in your heart, you know what this is; you just cannot believe it is happening to this healthy young patient, who was the very first from a new referral source, and on such a bright sunny morning.

Solution

You immediately ask the anesthesiologist to interrogate the aorta for potential dissection using transesophageal echocardiography. They confirm your worst fears and report a dissection flap in the descending aorta. The dissection flap involves the ascending aorta and extends into the sinus segment, causing mild-to-moderate aortic regurgitation. Since you are unable to adequately flow on cardiopulmonary bypass, your first priority is to establish alternative arterial cannulation. You have not yet arrested the heart, so you wean from bypass and expeditiously perform a groin incision to expose the femoral artery, which thankfully does not appear dissected. You carefully cannulate the femoral artery, switch perfusion to the new cannula, and gradually resume cardiopulmonary bypass. The perfusionist informs you that they can flow a rate of 2.4 L/min/m^2 with normal line pressures. Now that you have adequate bypass flow, you begin to cool the patient to 18°C in preparation for circulatory arrest. When the heart fibrillates, you cross clamp the aorta and deliver retrograde cardioplegia. You open the ascending aorta through a transverse incision and notice the dissection flap that extends distally into the area of the cross-clamp. You identify the coronary ostia and carefully provide additional cardioplegia directly into the coronary arteries using ostial cardioplegia catheters and achieve a quick diastolic arrest. You carefully examine the aortic root. The dissection flap extends into the non-coronary sinus but does not involve the left or right coronary sinuses, or the coronary ostia. You are relieved to see there are no intimal tears in the root. You prepare the proximal aorta for anastomosis at the level of the sinotubular junction using a “felt sandwich” technique, attaching strips of Teflon felt both inside and outside the aorta using a loosely run prolene suture. While you continue to cool, you perform the unroofing of the LAD myocardial bridge, which by now has become an “incidental” portion of the operation. Once the patient is at 18°C , you halt the cardiopulmonary bypass, remove the cross-clamp, and examine the aortic lumen. This enables you to identify a 1 cm laceration in the posterior wall of the ascending aorta at the level of the aortic cannula. You are relieved to see that the intimal tear is limited to the ascending aorta and does not extend into the aortic arch. You resect the entirety of the intimal