



Clinical Care Improvement Strategies:

Preventing Air Embolism



Senior Editor: Audrie Bretl Roelf, M.A.

Project Manager: Andrew Bernotas

Manager, Publications: Paul Reis

Associate Director, Production: Johanna Harris

Executive Director: Catherine Chopp Hinckley, Ph.D.

Joint Commission/JCR Reviewers: Paul Reis, Patricia Adamski, Mary Brockway, Deborah Nadzam

Joint Commission Resources Mission

The mission of Joint Commission Resources (JCR) is to continuously improve the safety and quality of health care in the United States and in the international community through the provision of education, publications, consultation, and evaluation services.

Joint Commission Resources educational programs and publications support, but are separate from, the accreditation activities of The Joint Commission. Attendees at Joint Commission Resources educational programs and purchasers of Joint Commission Resources publications receive no special consideration or treatment in, or confidential information about, the accreditation process.

The inclusion of an organization name, product, or service in a Joint Commission Resources publication should not be construed as an endorsement of such organization, product, or service, nor is failure to include an organization name, product, or service to be construed as disapproval.

This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. Every attempt has been made to ensure accuracy at the time of publication; however, please note that laws, regulations, and standards are subject to change. Please also note that some of the examples in this publication are specific to the laws and regulations of the locality of the facility. The information and examples in this publication are provided with the understanding that the publisher is not engaged in providing medical, legal, or other professional advice. If any such assistance is desired, the services of a competent professional person should be sought.

© 2010 The Joint Commission

Joint Commission Resources, Inc. (JCR), a not-for-profit affiliate of The Joint Commission, has been designated by The Joint Commission to publish publications and multimedia products. JCR reproduces and distributes these materials under license from The Joint Commission.

All rights reserved. No part of this publication may be reproduced in any form or by any means without written permission from the publisher.

Printed in the U.S.A. 5 4 3 2 1

Requests for permission to make copies of any part of this work should be mailed to
Permissions Editor
Department of Publications
Joint Commission Resources
One Renaissance Boulevard
Oakbrook Terrace, Illinois 60181
permissions@jcrinc.com

ISBN: 978-1-59940-389-2

Library of Congress Control Number: 2010928254

For more information about Joint Commission Resources, please visit <http://www.jcrinc.com>.

Contents

- Introductioniv**
 - Purpose and Intended Audienceiv
 - Why Preventing Air Embolism Is Importantv
 - Challenges to Preventing Air Embolismvii
 - Contents of This E-Bookviii
- Acknowledgmentsx**
- Chapter 1: The Current State of Air Embolism in Health Care1**
 - How Does an Air Embolism Occur?1
 - When Are Patients at Increased Risk for Air Embolism?2
 - Air Embolism as a Never Event7
 - How Much Air Can the Body Tolerate?11
 - How Does an Air Embolism Affect Patient Safety?11
- Chapter 2: Preventing Air Embolism16**
 - Preventing Air Embolism During Surgical Procedures16
 - Preventing Air Embolism During Medical Procedures39
- Chapter 3: Detecting an Air Embolism and Mitigating Its Effects59**
 - Detecting Air Embolism Using Monitoring Devices59
 - Mitigating the Effects of an Air Embolism64
- Index67**

Introduction

Purpose and Intended Audience

This e-book compiles the latest information on the current state of air embolisms in the health care setting, including the medical and surgical procedures that place patients at the greatest risk. Furthermore, this e-book describes the various monitoring devices that can be used during these at-risk medical and surgical procedures to identify air embolism early and allow clinicians to mitigate the effects of an air embolism as soon as possible. The purpose of this e-book is to describe research and strategies for preventing and mitigating the effects of air embolisms so that health care organizations can create or amend their air embolism prevention programs with ease and efficiency.

The intended audience of this e-book is health care organizations that want to do the following:

- Significantly decrease the incidence of air embolism or prevent patients from experiencing air embolisms altogether
- Improve patient safety and satisfaction by reducing harm and pain caused to patients by air embolisms
- Reinforce staff education and improve staff compliance with air embolism–prevention protocols
- Ensure that clinicians understand how to monitor and mitigate the effects of air embolisms
- Reduce costs associated with treating the effects of air embolisms, given that the Centers for Medicare & Medicaid Services (CMS) will no longer pay for *never events* (events that should never occur in a health care organization) such as health care–acquired air embolisms
- Comply with The Joint Commission’s recommendations contained in the *Sentinel Event Alert* on tubing misconnections
- Reduce liability stemming from injuries with air embolism (for example, litigation against the organization and its employees)

This e-book is directed toward health care organizations that perform surgical and medical procedures that place patients at high risk for air embolism. Surgical procedures that place patients at high risk for air embolism include the following:

- Surgery in the sitting position (including neurosurgery)
- Surgeries involving cardiopulmonary bypass
- Cesarean section
- Laparoscopic surgery*
- Hysteroscopy
- Orthopedic surgeries, including arthroscopy* and hip replacement
- Gastrointestinal endoscopy

Medical procedures that put patients at greatest risk for air embolism include insertion and removal of peripheral or central venous catheters/sheaths, infusion therapies through those catheters, mechanical ventilation, contrast injection, and hemodialysis. Although other medical and surgical procedures may also put patients at risk for air embolism, researchers and clinicians have demonstrated the previously listed medical and surgical procedures to have increased risks for air embolism.

Why Preventing Air Embolism Is Important

Air embolisms would be nearly nonexistent if not for medical or surgical procedures. The very procedures that may save patients' lives also subject them to the two conditions that must be simultaneously present to cause an air embolism¹⁻³:

- Direct communication between a source of air and a blood vessel (that is, a blood vessel that is open to air).
- A pressure gradient favoring the passage of air into a blood vessel (wherein air flows from the higher atmospheric pressure to the lower vasculature pressure). This negative pressure gradient has the effect of pushing air into the vasculature; the greater the pressure gradient, the more rapidly air is drawn into the vasculature.

In addition, certain surgical procedures present another condition that increases the risk for both venous and arterial air embolism. These surgeries, including laparoscopic, arthroscopic, and hysteroscopic procedures and gastrointestinal endoscopies, use liquid, air, or gas (usually carbon dioxide) to improve visualization during the procedure.

* Although *air* embolisms rarely occur during laparoscopic and arthroscopic surgeries, gas embolisms can occur as carbon dioxide (CO₂) is used as a distending agent to visualize the surgical field better. See more about gas embolisms in the box titled "What Is the Difference Between an Air Embolism and a Gas Embolism?" in Chapter 1 (page 8) and in Chapter 2, where laparoscopic and arthroscopic surgeries are discussed in further detail.

The distention medium used during these procedures further increases the pressure gradient to push air into the vasculature at a greater rate.

“Air embolism is truly a complication that has little or nothing to do with the primary procedure,” says Marek A. Mirski, M.D., Ph.D., professor, Department of Anesthesiology and Critical Care Medicine, Johns Hopkins Medical Institutions, Baltimore. In other words, if patients were not exposed to the medical and surgical procedures that present a high risk for air embolism, they would have essentially no risk for air embolism (except in the case of traumatic injury). Patients can have a variety of adverse outcomes, depending on the amount of air, the rate at which the air enters the vasculature, and where the air enters the vasculature. Some patients can tolerate small amounts of air at a slow rate without showing any symptoms, and these air embolisms likely go unnoticed unless extremely sensitive monitoring devices are present. However, if a large amount of air quickly enters the vasculature, patients may experience right ventricular outflow obstruction—which can lead to cardiovascular collapse, reduced cardiac output and blood pressure, and ischemia to vital organs in the body—as well as many other complications.^{1–3} In addition, patients rarely can tolerate even small amounts of air in the arterial system, as the air causes immediate ischemia to any cells or organs along its path.² Clinicians must make every effort possible to prevent fatalities or other unnecessary harm due to air embolisms.

Furthermore, the CMS has categorized air embolism as one of its never events and will no longer pay health care organizations for the extra costs associated with health care–acquired air embolisms. By not paying for air embolisms, the CMS hopes to give health care organizations the extra motivation to prevent the 57 air embolism cases that occurred in Medicare patients in 2007.⁴ “When we have administrative decisions like this one from the CMS, it elevates the attention to the problem because there is no better way to hit someone than in the pocket. It is unfortunate but true,” says Mirski. In addition, the National Quality Forum (NQF) includes air embolism on its list of 28 serious reportable events (also known as *never events*).⁵

online extras

Visit the online extras page, at <http://www.jcrinc.com/EBPAE10/Extras/>, for more information on National Quality Forum never events with the Centers for Medicare & Medicaid Services 2010 Call for Measures Table.

Challenges to Preventing Air Embolism

Air embolisms are preventable, but in some cases—especially surgical procedures where many veins potentially can be cut and exposed to air—this may be difficult. For example, positioning is extremely important in reducing the risk of air embolism during medical and surgical procedures, as the operative site should not be above the level of the heart. However, this optimum positioning to reduce air embolism may not always be achievable if it does not allow the surgeon to perform the surgery safely or if it puts the patient at increased risk for other complications, such as hemorrhage. Therefore, when deciding on positioning, clinicians may have to weigh the risk of air embolism against the risks of other complications as well as the benefits of performing a surgery in a certain position (such as improved visualization of the surgical site, reduced bleeding, improved patient ventilation). For certain surgeries and positions the risk of air embolism is extremely high (such as neurosurgeries in the sitting position). Surgeons may opt to perform such a surgery in a different position to reduce the risk for air embolism. However, for other surgeries air embolism does not present as great a risk, so physicians will not choose the optimal position for reducing the risk of air embolism. This is the case with cesarean section, wherein the risk of air embolism is greatly reduced if the patient is placed in reversed Trendelenburg (or supine) position during the procedure. However, this position does not facilitate the surgery and increases the patient's risk for hemorrhage; therefore, the Trendelenburg position is often favored, even though it increases the risk for air embolism. In this case, the benefits to using the Trendelenburg position outweigh the risk of air embolism.

Another challenge in preventing patient harm from air embolism is that an air embolism can be difficult to diagnose, especially if clinicians are not keenly aware of the various signs and symptoms that may present when an air embolism occurs. There is no hallmark of an air embolism that can immediately tip clinicians off to its presence. Instead, air embolism can present in a variety of ways, depending on where the air enters the body, how fast the air enters the body, and how much air enters the body.¹ Thus, clinicians must know when patients are at increased risk for air embolism and must gather information from the patient and various monitoring devices to determine whether the patient might be experiencing an air embolism. Clinicians must act fast to prevent further harm from the air embolism once it is suspected.

An air embolism, particularly a venous one, may not present with any signs or symptoms because the body is able to tolerate the air. Therefore, many clinicians may

have never seen a patient experience an air embolism in their career or they may not have been aware that a patient experienced an air embolism because the symptoms were too vague (such as hypotension and decreased end-tidal carbon dioxide levels). “There is some literature that supports that the occurrence of air embolism is much more common than we probably think,” says Mirski. “And when we look for air embolisms with sensitive monitoring devices, we often find them.” Due to the assumed infrequency of air embolisms, clinicians may not think air embolisms are a threat to patients, or air embolism simply may not be at the forefront of their minds as they go about providing patient care. But air embolisms can occur during even the most mundane of practices, such as when a clinician administers an intravenous push medication and lets any air that remains in the syringe go into the patient or when a family member tries to help but accidentally connects the noninvasive blood pressure insufflation tubing to a needleless IV port, accidentally pushing air into the intravenous catheter. “I think clinicians are aware of air embolisms, but they tend to believe a patient can tolerate quite a bit of air,” says Bruce C. Hansel, Ph.D., C.C.E., executive director, Forensic Services, ECRI Institute, Plymouth Meeting, Pennsylvania. For this reason, clinicians, nonmedical staff, students, patients, and family members should all be educated on the potential dangers of air embolism and should know what they can do to prevent them from occurring.

Contents of This E-Book

The following is a brief overview of the three chapters in this e-book:

- Chapter 1 describes the current state of air embolisms and what is being done to prevent them. In addition, this chapter also explains the pathophysiology of how an air embolism occurs within the body, how much air is needed to affect patients adversely, and what medical and surgical procedures place patients at increased risk for air embolism. Finally, this chapter describes how air embolisms affect patient safety.
- Chapter 2 discusses the various medical and surgical procedures that put patients at increased risk for air embolism and describes the prevention strategies unique to those medical and surgical procedures that can keep patients safe. This chapter also discusses patient and family education, especially as it involves patient and family member use of infusion devices in the home.
- Chapter 3 focuses on signs that an air embolism may be occurring as well as monitoring devices that can help clinicians identify an air embolism early enough to mitigate any effects the air embolism might have on the patient. Finally, this chapter concludes with tips on how to mitigate the effects of air embolism and to prevent any permanent harm to the patient.

References

1. Mirski M.A., et al.: Diagnosis and treatment of vascular air embolism. *Anesthesiology* 106:164–177, Jan. 2007.
2. O'Dowd L.C., Kelley M.A.: Air embolism. *Up to Date* 16(2):1–15, Sep. 21, 2007.
3. Natal B.L., Doty C.I.: *Venous Air Embolism*. eMedicine. <http://emedicine.medscape.com/article/761367-overview> (accessed Jan. 8, 2010).
4. Department of Health and Human Services: Changes to the Hospital Inpatient Prospective Payment Systems and Fiscal Year 2008 Rates. *Fed Regist* 73:48433–49084, Aug. 19, 2008.
5. National Quality Forum: *Serious Reportable Events: Transparency & Accountability Are Critical to Reducing Medical Errors*. Oct. 2008. http://www.qualityforum.org/Publications/2008/10/Serious_Reportable_Events.aspx (accessed Feb. 22, 2010).

Acknowledgments

Joint Commission Resources (JCR) relies on the insight, perspective, and experiences of many individuals and organizations to help shape and contribute to its publications. JCR would like to thank all of the reviewers and content experts at The Joint Commission and JCR who helped conceptualize, develop, and ensure the accuracy of this e-book's contents. It would also like to thank the following people for sharing their expertise and knowledge:

- Marek A. Mirski, M.D., Ph.D., professor, Department of Anesthesiology and Critical Care Medicine, Johns Hopkins Medical Institutions, Baltimore
- Bruce C. Hansel, Ph.D., C.C.E., executive director, Forensic Services, ECRI Institute, Plymouth Meeting, Pennsylvania
- Jeffrey B. Riley, M.H.P.E., C.C.T., C.C.P., supervisor and educational coordinator, Cardiovascular Perfusion Work Group, Mayo Clinic, Rochester, Minnesota
- William Camann, M.D., director of Obstetric Anesthesiology, Brigham and Women's Hospital, Boston

Furthermore, JCR appreciates the extra time Mirski and Hansel took to review the entire e-book for its accuracy and readability. Finally, JCR extends a special thank you to Meghan Pillow, R.N., for her time and talent in writing this book.