Actionable Patient Safety Solutions (APSS):

Air Embolism

How to use this guide

This guide gives actions and resources for air embolism. In it, you'll find:

المركز السعودي لسلامة المرضى
SAUDI PATIENT SAFETY CENTER

Patient Safety MOVEMENT

Executive Summary

The Problem

Because 15% of air embolism cases are asymptomatic and nearly all are sudden, standardized, universal prevention procedures are essential to reduce the occurrence (McCarthy et al., 2017). The prevention techniques are already available in most hospitals, and therefore require little additional investment, but require prioritization and bundling to ensure consistency in delivery of air embolism prophylaxis.

The Cost

Air embolism cases, although rare, can have significant clinical implications, such as neurological damage and death, and are associated with a 3.3% mortality rate (Aujesky et al., 2008). The cost of treatment is estimated to be approximately $8,000-$12,000 per patient, as the damage is significant, if the patient even survives. When compared to the cost to prevent, the cost to treat is significantly higher and more burdensome to the organization and all individuals involved.

The Solution

Many healthcare organizations have successfully implemented and sustained improvements and reduced death and harm from air embolism cases. These organizations have focused on projects that included **standardization, consistency, and prioritization of air embolism prophylaxis**.

This document provides a blueprint that outlines the actionable steps organizations should take to successfully reduce air embolism cases and summarizes the available evidence-based practice protocols. This document is revised annually and is always available free of charge on our website. Hospitals who make a formal commitment to improve air embolism safety and share their successes on the PSMF website have access to an additional level of consulting services.

Leadership Checklist

On a monthly basis, or more frequently if a problem exists, the executive team should review the outcomes of patients at risk for air embolism. Use this checklist as a guide to determine whether current evidence-based guidelines are being followed in your organization:

- ☐ Measure and report the incidence of air embolism.
- ☐ If air embolism incident rates indicate room for improvement, initiate a PI (performance improvement) project. If a problem is not indicated, routinely reassess to identify gaps, and ensure integrity of the data collected.
- ☐ Ensure frontline involvement in air embolism prevention improvement activities. Maintain their engagement and remove barriers to progress.
- ☐ If a PI plan is put in place, measure the associated process outcomes.
- ☐ Ensure that air embolism prevention protocols are embedded into clinical workflows, whether electronic or paper.
- ☐ Ensure there are enough staff to effectively manage necessary preventive care.
- ☐ Ensure adequate training and documentation of air embolism prevention competencies and skills.
- ☐ Eliminate barriers to making rapid changes to documentation templates and order sets.
- ☐ Debrief on a regular basis to solicit team feedback about barriers to sustained compliance. Adjust the plan quickly and nimbly as needed.
- ☐ Hold staff accountable for providing the standard of care and reward success.
- ☐ Ensure that leaders have a simple process to oversee air embolism prevention improvement work while also considering how it aligns with other initiatives across the organization.
- ☐ Implement an electronic health records (EHR) system with decision-making support to ensure that every patient has an air embolism prevention and detection plan in place at all times during hospitalization.
- ☐ Educate clinicians on technologies that reduce the number of air embolism by preventing, detecting, and actively removing air in intravenous access lines.
- ☐ Establish a protocol to test physician competencies of placement of central venous catheters to prevent air embolism.
- ☐ For each potential air embolism cause, develop a checklist protocol for all caregivers to follow to avoid air embolism events.
    - Example: Pressurized intravenous infusion systems.
        - Eliminate all air from IV infusion bags before connecting to a patient.
        - Use an air detection technology to detect and eliminate air from infusion tubing.

Clinical Workflow Infographic

ADMISSION

Conduct a risk assessment and consider patient risk factors, especially those associated with planned procedures during hospitalization.

PREVENTION

Assess risk for higher risk groups, including (O'Dowd and Kelley, 2020):

- Patients undergoing endovascular procedures
- Patients with right-to-left shunt anatomy, including patent foramen ovale (PFO), patent ductus arteriosus (PDA), atrial septal defect (ASD), etc.
- Patients who need large volumes of intravenous fluids, or rapid infusions using pressurized systems (such as major trauma surgery)
- Patients who have or need central venous access of any type
- Patients who will undergo a high-risk surgical procedure or surgery in a high-risk position (such as a surgery site above the heart)

In the following high-risk patient populations, follow procedural precautions to reduce likelihood of air embolism.

Those undergoing neurosurgical procedures:

- Monitor with transthoracic or transesophageal echocardiography.
- Discontinue anesthesia with nitrous oxide.

Those on a ventilator:

- Minimize airway pressures to prevent pulmonary barotrauma. To prevent pulmonary barotrauma, use lung protective approaches (Hyzy et al., 2020):
  - Limit plateau pressure to ≤30 cm H2O.
  - Use low tidal volume ventilation (6 to 8 mL/kg ideal body weight).
- Limit ventilation exposure. Wean the patient from the ventilator as soon as possible based on clinical indications (See Ventilation Management Actionable Patient Safety Solution).

Those with central intravascular catheters:

- For central venous catheter insertion and removal, the Trendelenburg position is preferred for jugular and subclavian sites. For the femoral location, the supine position is preferred.
- Treat hypovolemia prior to placing the catheter.
- Block the hub of the central venous catheter during insertion.
- Maintain closure of all connections to the central line.
- Ask the patient to perform the Valsalva maneuver when removal is necessary.
- Keep the patient supine when drawing blood or administering medications.

Air embolism risk can be reduced by incorporating small practices into routine care (McCarthy, Behravesh, Naudi, & Oklu, 2016).

- When placing and removing central venous catheters:
  - Place patient in Trendelenburg position.
  - Ensure the patient is adequately hydrated.
  - Avoid placement of venous catheters during inhalation when negative intrathoracic pressure is at its highest point.
  - Avoid a short subcutaneous path to the jugular vein.
  - Occlude the needle hub with thumb in the absence of a guide wire.
  - Flush all catheter lumens before placement.
  - Make sure the venotomy site is below the level of the heart upon removal.
  - Have the patient perform a Valsalva maneuver upon removal or remove the catheter upon exhalation.
- During an angiogram:
  - Identify high-risk patients in advance.
  - Use a continuous flush through a closed system.
  - Hold syringes upright to ensure that any air travels away from the catheter.
  - Connect syringe from wet to wet end.
  - Do not inject complete volume of syringe.
  - Use air-in-line detection devices.

See the "Detection" section for more information

DETECTION

Use monitors for air embolism detection.

- Trans-esophageal echo (TEE)
- Precordial Doppler
- Transcranial Doppler
- Pulmonary artery catheter
- End-tidal nitrogen

Be aware of air embolism symptoms in a conscious patient.

- Chest pain
- Dyspnea
- Shortness of breath
- Unconsciousness or decreased level of consciousness

Be aware of air embolism clinical signs.

- Hypotension
- Decreased end-tidal CO2
- Rapid or irregular heartbeat
- "Mill-wheel" murmur
- Peaked P-waves on ECG
- Decreased SpO2 (late sign)

Signs and symptoms are dependent on the volume of air. See the signs and symptoms by volume table in the "What We Know" section.

MANAGEMENT

As soon as an air embolism is suspected, steps should be taken immediately to prevent further air embolism.

- Prevent further air entrainment by removing the underlying cause.
  - If an intra-arterial cannula is present, stop the flush immediately and fully open the rotating hemostatic valve. Allow the arterial pressure to slowly push the air back out or enhance the process by turning the system vertically.
- If the patient is unresponsive, address airway, breathing, and circulation and initiate CPR as needed.
- Activate rapid response team or call additional staff for help.
- Use pharmacological hemodynamic support as needed to maintain blood pressure and organ perfusion, including inotropes (dobutamine) and vasoconstrictors (phenylephrine, norepinephrine) to support systemic blood pressure.
- Once stabilized, examine the patient, physically and neurologically, and administer 100% oxygen via a non-rebreather to minimize the size of the air embolus.
- In the case of a venous air embolism, perform Durant's maneuver (45-degree left-side down position) and keep the patient in the flat supine position, as a head down position has been suggested to worsen the cerebral edema.
- Activate cardiopulmonary resuscitation as indicated.
- Advanced management may include the initiation of pressors and mechanical ventilation.
  - Use Positive End-Expiratory Pressure (PEEP) on ventilator during high-risk procedures on mechanically-ventilated patients
- Aspiration may be necessary in the event of an air lock of the right ventricular outflow tract. See Garg et al. for the intracardiac aspiration for a life-threatening air embolism.

Performance Improvement Plan

Follow this checklist if the leadership team has determined that a performance improvement project is necessary:

- [ ] **Gather the right project team.** Be sure to involve the right people on the team. You'll want two teams: an oversight team that is broad in scope, has 10-15 members, and includes the executive sponsor to validate outcomes, remove barriers, and facilitate spread. The actual project team consists of 5-7 representatives who are most impacted by the process. Whether a discipline should be on the advisory team or the project team depends upon the needs of the organization. Patients and family members should be involved in all improvement projects, as there are many ways they can contribute to safer care.

Complete this Lean Improvement Activity:
Conduct a SIPOC analysis to understand current state and scope of the problem. A SIPOC is a lean improvement tool that helps leaders to carefully consider everyone who may be touched by a process, and therefore, should have input on future process design.

RECOMMENDED AIR EMBOLISM PREVENTION AND IMPROVEMENT TEAM	
• Admitting and registration staff	• Quality and safety specialists
• Physicians	• Risk management specialists
• Nurses	• Pharmacists
• Physical therapists	• Information technologists
• Occupational therapists	• Rapid response team members
• Residents	

Table 1: Understanding the necessary disciplines for an air embolism prevention improvement team

- [ ] **Understand what is currently happening and why.** Reviewing objective data and trends is a good place to start to understand the current state, and teams should spend a good amount of time analyzing data (and validating the sources), but the most important action here is to go to the point of care and observe. Even if team members work in the area daily, examining existing processes from every angle is generally an eye-opening experience. The team should ask questions of the frontline during the observations that allow them to understand each step in the process and identify the people, supplies, or other resources are needed to improve patient outcomes.

Create a process map once the workflows are well understood that illustrates each step and the best practice gaps the team has identified (IHI, 2015). Brainstorm with the advisory team to understand why the gaps exist, using whichever root cause analysis tool your organization is accustomed to (IHI, 2019). Review the map with the advisory team and invite the frontline to validate accuracy.

AIR EMBOLISM PREVENTION PROCESSES TO CONSIDER ASSESSING	
• Central line placement procedures	• Activation of rapid response
• Process of diagnosis	• Patient positioning
• Indications used for detection	

Table 2: Consider assessing these processes to understand where the barriers contributing to air embolism rates may be in your organization

- [ ] **Prioritize the gaps to be addressed and develop an action plan.** Consider the cost effectiveness, time, potential outcomes, and realistic possibilities of each gap identified. Determine which are a priority for the organization to focus on. Be sure that the advisory team supports moving forward with the project plan so they can continue to remove barriers. Design an experiment to be trialed in one small area for a short period of time and create an action plan for implementation.

The action plan should include the following:

- Assess the ability of the culture to change and adopt appropriate strategies
- Revise policies and procedures
- Redesign forms and electronic record pages
- Clarify patient and family education sources and content
- Create a plan for changing documentation forms and systems
- Develop the communication plan
- Design the education plan
- Clarify how and when people will be held accountable

TYPICAL GAPS IDENTIFIED IN AIR EMBOLISM PREVENTION	
• Staff perception of importance of air embolism precautions • Knowledge of clinical indications of air embolism • Lack of understanding of personalized roles in air embolism prevention	• Poor methods for detection • Length of time between suspicion and rapid response team activation

Table 3: By identifying the gaps in air embolism prevention compliance, organizations can tailor their project improvement efforts more effectively

- [ ] **Evaluate outcomes, celebrate wins, and adjust the plan when necessary.** Measure both process and outcome metrics. Outcome metrics include the rates outlined in the leadership checklist. Process metrics will depend upon the workflow you are trying to improve and are generally expressed in terms of compliance with workflow changes. Compare your outcomes against other related metrics your organization is tracking.

Routinely review all metrics and trends with both the advisory and project teams and discuss what is going well and what is not. Identify barriers to completion of action plans, and adjust the plan if necessary. Once you have the desired outcomes in the trial area, consider spreading to other areas (IHI, 2006).

It is important to be nimble and move quickly to keep team momentum going, and so that people can see the results of their labor. At the same time, don't move so quickly that you don't consider the larger, organizational ramifications of a change in your plan. Be sure to have a good understanding of the other, similar improvement projects that are taking place so that your efforts are not duplicated or inefficient.

Read this paper **from the Institute for Healthcare Improvement to understand how small local steps can integrate into larger, system changes**

AIR EMBOLISM COMPARATIVE OUTCOMES
• Length of stay • Readmission • Transfer to ICU • Rapid response team activation

Table 4: Consider evaluating related metrics to better understand air embolism presence and contributing factors

What We Know About Air Embolism

Air embolism is the presence of gas (usually air) in the circulatory system. In the hospital setting, air embolism is usually the result of inadvertent injection of air into the venous system. Specifically, when a blood vessel is open to air and there is a pressure gradient favoring the passage of the air into the blood vessel, air can be drawn into the vasculature. Exposure to medical and surgical procedures present a high risk for air embolism, so much so that without these procedures, patients would have little to no risk of air embolism.

Inadvertent air injections can be sudden, as from an air-filled syringe or pumping system, or gradual, as through a continuous IV infusion. If gradual, it may not cause symptoms until serious damage to the pulmonary circulation has occurred. A patient's ability to tolerate and compensate for air embolism is variable, depending on general health status and presence of specific diseases (e.g., cerebrovascular).

Because CMS has categorized air embolism as one of its never events, meaning hospitals will not be reimbursed for the additional costs associated with hospital-acquired air embolisms, healthcare organizations have prioritized their prevention in recent years.

Although air embolisms are preventable, prevention is difficult. For example, patient positioning can be leveraged to prevent air embolisms. However, the optimal positioning to reduce air embolism may put the patient at risk for other complications. It is important to assess the risks and benefits of optimal positioning to prevent air embolism with risks for other complications during surgery.

Clinicians also face the challenge of recognizing and diagnosing air embolisms. **There is no hallmark sign or symptom and the air embolism can manifest in various ways.** Thus, an understanding of which patients are at an increased risk and when patients may be at a heightened risk can prepare the care team in the case of suspected air embolism, based on information from the patient and monitoring devices.

The vagueness of symptoms and subsequent lack of clinical experience in diagnosis can cause clinicians to think air embolisms are less common than is truly accurate. Consequently, they may not always be vigilant for recognition and prevention when providing care. However, because **air embolisms can occur in virtually any setting when even just administering an intravenous medication,** healthcare providers across the board should be educated and aware of the importance of air embolism prevention.

Right-left shunts, certain surgeries, and cannulation increase the risk of an air embolism.

Right-left shunt: The risk of AE becomes more immediately serious in patients with any form of right-left shunt (an opening that allows blood to flow from the right side of the heart to the left), such as patent foramen ovale (PFO), atrial septal defect (ASD) or patent ductus arteriosus (PDA). 25-30% of healthy adults have PFO, and most of these are asymptomatic and undiagnosed (Hagen, Scholz and Edwards, 1984). For any patient with a known diagnosis of potential right-left shunt, the increased risk of air embolism must be documented in the EMR and clearly explained to all care-team members.

Certain surgeries: The brain is particularly vulnerable to air embolism, where even a few milliliters of air can cause a major stroke. A retrospective case study showed that air embolism occurred in 100 of 400 patients who underwent craniotomy in the seated position – an incidence of 25% (Albin, 2011). Other surgical procedures that create high risk for air embolism include cardiopulmonary bypass, in which there are many reports of fatal cases (van, Koene and Mariani, 2014; Robich et al., 2017), as well as intrathoracic surgery, major joint surgery, Cesarean section, eye surgery (Gayer et al., 2016), pacemaker placement (Xiao et al., 2016), and major trauma. See "Surgical Procedures Associated with Vascular Air Embolism" and "Examples of Nonoperative Procedures Associated with Vascular Air Embolism" for a more comprehensive list of high-risk events and "Relative Risk of Air/Gas Embolism" for delineation of procedures by risk.

Cannulation: An air embolism can also occur when any type of intravascular cannula is used. This includes standard peripheral intravenous catheters, central venous catheters, pulmonary artery catheters, dialysis catheters, and arterial catheters. Pressurized intravenous infusion systems create a particularly serious risk of massive venous air embolism. One-liter plastic bags of intravenous contain up to 150 cc of air. If this air is not carefully removed before the fluid bag is placed in a pressurized device, it can be forcefully pumped into the patient's vein. There have been a number of published case reports of fatal or near-fatal air embolism from this mechanism (Adhikary and Massey, 1998; Aldridge, 2005). Central circulation catheters (CVP, PA, "triple lumen", etc.) pose an even higher risk. If such a catheter becomes disconnected and exposed in a sitting patient who spontaneously breathes, the pressure from inhaling can rapidly suck massive amounts of air directly into the heart, with fatal results.

The volume of air and the rate of accumulation directly influence the morbidity and mortality of air embolism (Mirsky et al., 2007). Although the amount of air necessary to provoke circulatory failure is debated, it has been suggested that the lethal volume is approximately 200-300 mL (Mirsky et al., 2007), while other studies suggest that less than 50 mL of air is required (Feil, 2015). Both the volume and rate of the air accumulation are dependent on the size of the opening and the pressure gradient (Mirsky et al., 2007).

Signs and symptoms are dependent on the volume of air (table adopted from Mirsky et al., 2007).

SMALL AMOUNT (<.5 ML/KG)	MEDIUM AMOUNT (.5-2.0 ML/KG)	LARGE AMOUNT (>2.0 ML/KG)
Decreased EtCO2 Increased EtN2 Oxygen desaturation Altered mental status Wheezing	Breathlessness Wheezing Hypotension Pulmonary hypertension Right heart strain Peaked P waves Jugular venous distension Myocardial ischemia Altered mental status Cerebral ischemia Bronchoconstriction Pulmonary vasoconstriction	Chest pain Right heart failure Cardiovascular collapse

Clinical Implications

Central lines are the most common source of air embolism in the emergency department, with an incidence in 1 in 40 to 1 in 3000 central line cases (Feil, 2015).

It has been suggested that the average length of stay for patients with pulmonary air embolism is approximately six days with a post-discharge mortality rate of approximately 3.3% (Aujesky et al., 2008). **It is important to note that in nearly 15% of cases, the patient may be completely asymptomatic** (McCarthy et al., 2017).

Although air embolism occurrence is rare based on reporting, it is suggested that many instances may go unreported. One study found that, upon analysis of 11,000 central venous catheter placements, there was an air embolism incidence of 1 in 772 (Vesely, 2001). Arterial air embolism has the potential to cause ischemia or infarction in any organ, even when the volume of air is small.

Air embolism can often be immediately lethal and due to the difficulty in diagnosis, prevention is key.

Financial Implications

Clinically, air embolism treatment can cost between $8,000 and $12,000 dollars per patient (Clearline, 2016). The damage from air embolism can range from brain damage, cerebral palsy, quadriplegia, and death and the legal settlement is typically in the millions.

Detection

Presentation is variable, nonspecific, and often sudden (Campbell, 2014). Air embolism should be considered as a possible diagnosis in these circumstances (Mirsky et al., 2007):

- Unexplained hypotension or decrease in EtCO2 in surgeries performed where the patient is in reverse Trendelenburg position
- Shortness of breath after insertion or removal of a central venous catheter
- Sustained hypotension or hypoxia post-cesarean delivery
- Neurological symptoms, including altered mental status and seizures

In patients under anesthesia, reduced end-tidal CO2 may be detected as the earliest indicator (McCarthy et al., 2016). Air-in-line devices in modern infusion pumps are helpful in the detection of bubbles within tubing. Precordial Doppler can also be employed during anesthesia where there is a high-risk for air embolism (McCarthy et al., 2016).

Methods of Detection of Air Embolism (adapted from Mirsky et al., 2007)

METHOD	SENSITIVITY	LIMITATIONS
Transesophageal Echocardiography	High	Expertise required, expensive, invasive, rarely available
Precordial Doppler Ultrasound	High	Obese patients
Pulmonary Artery Catheter	High	Fixed distance, small orifice
Transcranial Doppler Ultrasound	High	Expertise required
End-tidal Nitrogen	Moderate	N2O, hypotension
End-tidal Carbon Dioxide (unexplained decrease of 2mmHg)	Moderate	Pulmonary disease
Pulse Oximetry	Low	Late changes
Direct Observation	Low	No physiologic data
Esophageal Stethoscope	Low	Late changes
Electrocardiogram (sinus tachycardia, right heart strain, T-wave changes)	Low	Late changes

Resources

For air embolism improvement:

- NCBI: Air Embolism: Practical Tips for Preventions and Treatment
- NCBI: Acute Management of Vascular Air Embolism
- MDPI: Air Embolism: Practical Tips for Prevention and Treatment
- PSA: Reducing Risk of Air Embolism Associated with Central Venous Access Devices
- NIH: Venous Air Embolism During Home Infusion Therapy

For general improvement:

- CMS: Hospital Improvement Innovation Networks
- IHI: A Framework for the Spread of Innovation
- The Joint Commission: Leaders Facilitating Change Workshop
- IHI: Quality Improvement Essentials Toolkit
- SIPOC Example and Template for Download
- SIPOC Description and Example

Education for Patients and Family Members

The outline below illustrates all of the information that should be conveyed to the patient and family members by someone on the care team in a consistent and understandable manner.

Explain the etiology of an air embolism as it relates to the patient's circumstance and illustrate the prevention processes employed. The patient and their family members should understand what an air embolism is, how it occurs, and the clinical significance if detected. A member of the healthcare team should explain the air embolism risk factors, particularly those relevant to the patient themselves based on their circumstance. The patient and family members should understand that, although rare, air embolisms are extraordinarily hazardous and can cause significant complications. This should be followed up with all of the precautions the healthcare team is taking to prevent an air embolism.

Instead of employing a directive conversation style, an active, engaging conversation should take place, leaving capacity for questions and repeat-back strategies. When patients and family members understand the signs and symptoms that could be indicative of a problem, they are able to serve as an extra set of eyes in order to elevate this concern as early as possible.

Describe what can be anticipated. Clinicians should provide a high-level overview of the processes in place at their organization to ensure prevention of an air embolism before the procedure. This demonstrates competence of the organization, will likely bolster patient and family comfort, and will provide the patient and family members with information for which to reference if they may be suspicious of a problem during the entire process of care for the patient.

By engaging in these conversations before a problem arises, family members can be prepared in the circumstance of necessary treatment and will have an understanding of where to go to find out more information about their loved one's condition.

Explain what is expected of them during their care. By giving patients and family members a "job" while they are in the hospital, they can be immersed fully in the routine care, can hold other team members accountable, can feel more confident voicing their concerns or opinions, and can serve as an extra set of informed and vigilant eyes to optimize air embolism prevention. This team involvement can also reduce their anxiety by transforming concern into proactive action.

Patients and family members can:

- Engage in conversations around current potential health conditions, such as pre-existing respiratory diseases.
- Ask for clarification pertaining to the patient's condition and air embolism prevention.
- Monitor the patient for any of the following symptoms:
  - Low blood pressure
  - Tightness in the chest or chest pain
  - Shortness of breath
  - Muscle or joint pain
  - Stroke
  - Blue skin hue
  - Changes in mental status
- Understand the central venous catheter management process that is being practiced by the healthcare team.
- Post hospital treatment, encourage the patient to practice health lifestyle, which includes:
  - Weekly exercise routine
  - Healthy diet
  - Smoking cessation (if applicable)

Explore next steps. Planning for life after the hospital, whether in assisted living, returning home, or another option, should begin as early as possible between the healthcare providers and the patient and family.

- Discuss home infusion therapy with the patient and family members. If the patient will be undergoing home infusion therapy, advanced education on air embolism prevention is necessary to prevent introduction of air into the patient's line access. Help the patient understand the alarms on the pumps and the proper patient positioning (Laskey and Tobias, 2002).
  - Additional roles that might fall in the hands of the family members or the at home care aids may include the following:
    - Administering the proper medications with the proper dosage
    - Performing routine maintenance on central venous devices
- Have a discussion with the patient and family around end of life care and advanced directives.
  - Make an attempt to thoroughly understand the religious or cultural nuances in any of the patient's or family members' decisions or questions.
- Ensure thorough explanation of necessary post-discharge appointments, therapies, medications, and potential complications.
  - Assess for patient preference in time and location of follow-up appointments, if possible.

- Provide patients and family members resources, including direct contact phone numbers, to the hospital for post-discharge questions.
  - Make sure the resources are in their own language.

Patients and family members should understand that, although all clinicians in the hospital do their best, no one is ultimately coordinating their care. Patients and family members should understand that they are the managers of their care and as such, should demand to be an active part of the care team including conversations and decisions.

Each conversation with a patient and family member should be inclusive and void of bias. Additionally, these conversations should leave ample time for discussion and the facilitator should encourage questions from the patient and family members.

Measuring Outcomes

Because of the rarity in occurrence, incidence rate of air embolism is an appropriate metric for patient safety efforts and tracking improvement.

Endnotes

Conflicts of Interest Disclosure

The Patient Safety Movement Foundation partners with as many stakeholders as possible to focus on how to address patient safety challenges. The recommendations in the APSS are developed by workgroups that may include patient safety experts, healthcare technology professionals, hospital leaders, patient advocates, and medical technology industry volunteers. Workgroup members are required to disclose any potential conflicts of interest.

Workgroup

Co-Chairs

Brandyn Lau	Johns Hopkins Medicine
Michael Becker	Masimo
Vonda Vaden Bates	Patient Advocate; 10th Dot

Current Members

Steven J. Barker	Patient Safety Movement Foundation; Masimo
Lorraine Foley	Society for Airway Management
David Hughes	Patient Safety Movement Foundation, Do It For Drew Foundation
Josiah Huse	Patient Safety Movement Foundation
Arthur Kanowitz	Securisyn
Ariana Longley	Patient Safety Movement Foundation

Metrics Integrity

Robin Betts	Kaiser Permanente, Northern California Region

Previous Members

This list represents all contributors to this document since inception of the Actionable Patient Safety Solutions

Jim Augustine	US Acute Care Solutions
Ann Bilyew	ClearLine MD
Michel Bennett	Patient Safety Movement Foundation
Jestin Carlson	Allegheny Health Network
Richard Cooper	University of Toronto
Abbey Curran	ClearLine MD
Drew Fuller	Emergency Medicine Associates
Kate Garrett	Ciel Medical
Victor Grazette	Virginia Hospital Center
Hans Huitink	Vanderbilt University Medical Center
Thomas Kallstrom	American Association for Respiratory Care
Jacob Lopez	Patient Safety Movement Foundation
Ariel MacTavish	Medtronic
Rhea May	Medtronic
Kellie Quinn	Retired
Kenneth Rothfield	Medical City Healthcare
Michael Taylor	Fairview Hospital
Dianne Vass	Emergency Medicine Patient Safety Foundation

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