Anesthesia Quality Institute®
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Anesthesia Incident Reporting System (AIRS)

Case 2024-03: Problems and Solutions in Electrophysiology

We noted a thermal injury to the tongue from the esophageal cooling probe used for this cardiac ablation procedure. There was a focal injury on the anterior 1/3 of the tongue, 1x1 cm. This occurred despite use of the protective sheath supplied by the manufacturer.

The famed author and journalist Eric Sevareid said, "The chief source of problems is solutions." We are living in an era of rapid and unprecedented progress in medical technology. Driven by advances in hardware and software, and incentivized by the profits to be earned in an entrepreneurial health care system, new devices are appearing in our ORs and procedural suites every day. These include automated jigs for joint replacement, robots for intracavitary surgery, and minimally invasive tools for intravascular diagnosis and therapy. With every new technological advance, however, comes new, unintended consequences.

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The evolution of cardiac electrophysiology illustrates this issue. Techniques to reverse chronic and paroxysmal atrial fibrillation (AF) through minimally invasive catheter ablation of the left atrium were first developed 20 years ago and have progressed rapidly since then (*N Engl J Med* 2011;365:2296-304; *Cardiol Res Pract* 2018;2018:6276241). AF affects more than 5 million Americans, and patients with AF have twice the adjusted mortality of similar patients with normal sinus rhythm. The cost of treating AF was estimated at more than $6.5 billion in 2011.

AF is usually triggered by ectopic electrical activity arising in the muscular layers of the pulmonary veins, where they drain into the left atrium. Fibrillation is sustained in the presence of fibrotic or inflamed atrial tissue resulting from chronic cardiac disease. AF is a progressive disease, with initial paroxysmal events eventually becoming a chronic condition that no longer responds to cardioversion.

The progression of AF can be interrupted by creation of scar tissue in the left atrium that "walls off" the pulmonary veins, augmented by targeted disruption of ectopic foci in the atrium itself. Both cryotherapy cooling and radiofrequency heating have been used to create these lesions. Radiofrequency ablation is the more common approach, although a recent metanalysis demonstrated similar outcomes with either technique. Both therapies have been shown to be superior to traditional medical management of paroxysmal AF. In an ablation procedure, energy is delivered to targeted points in the atrium in a precise fashion via a catheter threaded centrally from the femoral vein and then across the interatrial septum. Advances in guidance technology using echocardiography, fluoroscopy, and magnetic impedance now allow the cardiologist to position the tip of the ablation catheter with a resolution less than 1 mm.

As the procedure has grown in popularity over the past two decades, technology to facilitate atrial ablation has improved rapidly. Whereas anesthesiologist participation in cardiac catheterization procedures was relatively uncommon prior to 2010, facilitation of procedures in the electrophysiology lab is now a routine request. Patients may receive either deep sedation or general anesthesia, depending on patient comorbidities and the preferences of both the patient and the cardiologist. Like other procedures based on new technology, the diffusion of AF ablation into common practice has required development and refinement of new anesthetic approaches as well as awareness and prevention of procedure-specific complications. The Table shows common adverse effects of AF ablation; many have since been mitigated by technological improvements, better diagnostics, or increased clinician awareness.

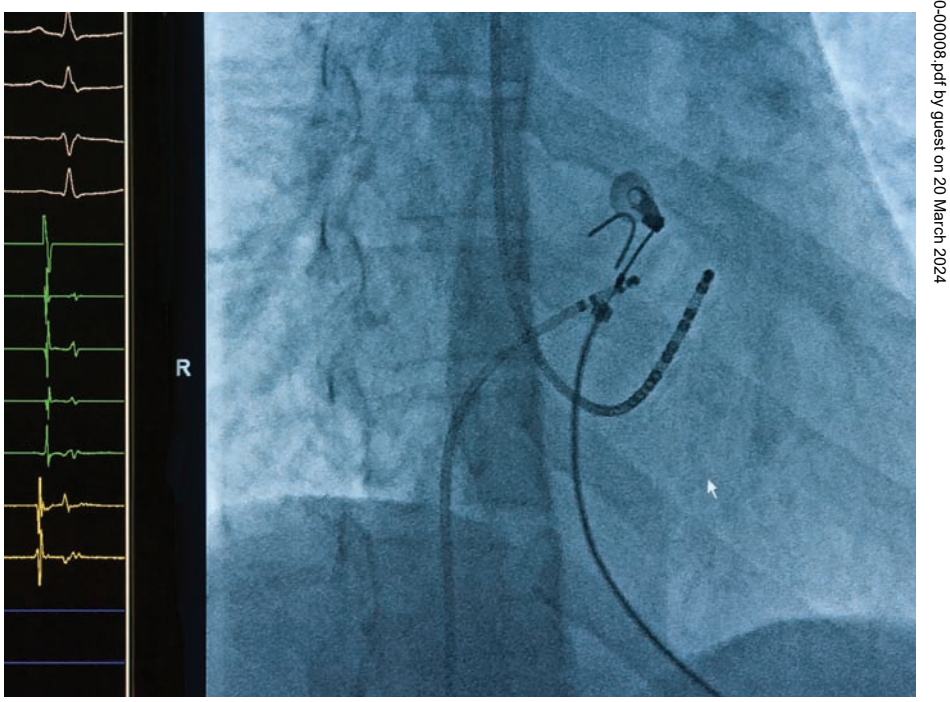
Adverse Effect	Mitigation
Cardiac tamponade	Clinician awareness, echocardiographic assessment
Stroke	Procedural anticoagulation
Pulmonary vein stenosis	Follow-up CT or MRI 3 months post-procedure
Phrenic nerve injury	Reassurance; usually resolves spontaneously
Esophageal injury	Temperature monitoring; active esophageal cooling

Table: Common adverse effects of atrial fibrillation ablation procedures (adapted from *N Engl J Med* 2011;365:2296-304).

One procedure-specific risk is injury to the esophagus due to radiofrequency heating of adjacent atrial tissue (*Gastroenterol Hepatol* 2012;8:414-6; *World J Gastroenterol* 2017;23:3374-8). The esophagus may be as close as 1 mm to the left atrium, with minimal intervening tissue. Evidence of thermal injury has been reported in as high as 47% of ablation patients. In rare cases, this can lead to esophageal perforation or atrio-esophageal fistula, which may prove fatal. Temperature monitoring in the atrium and esophagus is routine for ablation procedures, with elevated temperature in the esophagus leading to truncation or termination of the ablation procedure.

Ablation is a solution to AF but leads to the problem of esophageal injury. This problem, in turn, can be solved by use of another piece of new technology: a purpose-built esophageal cooling system that circulates cold fluid during the procedure (*J Innov Card Rhythm Manag* 2022;13:5236-43). Originally created to provide targeted temperature management for patients after cardiac arrest, the system has proven especially useful for esophageal cooling during atrial ablation, with excellent results for preventing injury to both the esophagus and the nearby vagus nerve (*Europace* 2021;23:205-15). As illustrated by this AIRS report, however, this solution can in turn cause its own complication: Unintended freezing of the tongue. The correspondent who reported the complication to AIRS noted that his group has subsequently begun wrapping the proximal portion of the cooling probe with additional insulation before placing it.

While not describing a major adverse outcome, this report illustrates the ongoing role of anesthesiologists in preserving patient safety. New technology enters practice every day, bringing with it new and unanticipated opportunities for injury. Our role as the guarantors of patient safety requires continued vigilance, metacognition, and situational awareness to recognize and mitigate new threats as they emerge. ■



X-ray showing the correct placement of catheter ablation for atrial fibrillation.

This entry was written by Dr. Richard Dutton on behalf of the AIRS Committee.

Each month, the AQI-AIRS Steering Committee abstracts a patient history submitted to AIRS and authors a discussion of the safety and human factors challenges involved. Absence of commentary should not be construed as agreement with the clinical decisions described. Reader feedback can be sent to **airs@asahq.org**. Report incidents at **www.aqiairs.org.**