Air Embolism during Insertion and Replacement of Tunneled Dialysis Catheters: A Retrospective Investigation of the Effect of Aerostatic Sheaths and Over-the-Wire Exchange

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ABSTRACT

Purpose: To determine the impact of the introduction of aerostatic sheaths on air embolism (AE) events during tunneled dialysis catheter (TDC) insertion and to characterize such events occurring during over-the-wire exchange (OTWE).

Materials and Methods: Between July 2001 and April 2013, 5,789 TDCs were placed, including 3,963 de novo placements, 1,811 OTWEs, and 15 tract recanalizations. There were 15 AE events reported, and the medical records of these patients were reviewed. The effect of aerostatic sheaths, introduced in July 2005, was compared with the period before their introduction; the same TDC design was used throughout.

Results: Of the 15 AE events, 10 occurred during de novo placement (10 of 3,963 placement; 0.25%), 4 occurred during OTWE (4 of 1,811 placements; 0.22%), and 1 occurred during tract recanalization. With regard to aerostatic sheaths in de novo TDC placement, 4 of 1,174 (0.34%) AE events occurred before aerostatic sheath introduction, and 6 of 2,789 (0.22%) AE events occurred after aerostatic sheath introduction. These rates did not differ statistically ($P = .5$).

Conclusions: Use of aerostatic sheaths trended toward reducing AE events during de novo TDC placement. This trend was not statistically significant, probably owing to the rarity of AE despite the large sample size. Air embolism occurs during OTWE at a rate similar to de novo placement with aerostatic sheaths as well as during tract recanalization.

ABBREVIATIONS

AE = air embolism, OTWE = over-the-wire exchange, TDC = tunneled dialysis catheter

Central venous catheters are commonly used in the care of medical and surgical patients. It is estimated > 5 million central venous access devices are placed each year in the United States (1). Among the complications that occur during insertion and removal of central venous catheters, air embolism (AE) is a potentially lethal, although preventable, one. Previous work demonstrated that the risk of AE is greatest during the process of tunneled catheter insertion through the peel-away sheath (2). Consequently, aerostatic sheaths have been developed to reduce this complication. Although in vitro testing has shown benefits with aerostatic sheath use, there are few clinical data investigating the risk of AE events during tunneled catheter placement with aerostatic sheaths (3,4). Additionally, over-the-wire exchange (OTWE) has become a standard of care in tunneled dialysis catheter (TDC) management as a means to preserve venous access, but little is known about the incidence of AE during OTWE (5–8). The purpose of this study was to determine the effect of aerostatic sheaths on AE events during insertion of TDCs and to characterize such events during OTWE.

MATERIALS AND METHODS

Approval from the institutional review board was obtained for this retrospective study, which was carried

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out in full compliance with the Health Information Accountability and Portability Act. Consent waiver was obtained. The interventional radiology database (Hi-IQ; Conexsys, Lincoln, Rhode Island), a (daily) prospectively acquired venous access quality assurance database, mortality and morbidity conference records, and a web-based radiology report search tool (Pathology-Radiology Enterprise Search Tool) were used to identify episodes of AE during TDC procedures (de novo placement, OTWE, tract recanalization) during the study period July 2001–April 2013. The search encompassed two large inner-city hospitals, which are part of the same health system and staffed by the same interventional radiology group. The operating physicians were board-certified and certified with or eligible for a certificate of added qualification with 1 to > 20 years of experience in venous access or trainees (residents, fellows) under the direct supervision of one of the interventional radiology attending physicians.

During the entire study period, the same 14.5-F TDC (Ash Split Cath; MedComp, Harleysville, Pennsylvania) was used. Catheter length was chosen to position the catheter tip in the right atrium with length ranging from 24–40 cm. All procedures were performed under strict sterile technique and moderate sedation. Real-time ultrasound guidance was used for all de novo procedures, and all procedures were carried out under fluoroscopic guidance. Catheters were placed via the internal jugular vein, external jugular vein, inferior vena cava, femoral vein, subclavian vein, and hepatic vein in decreasing order of preference in the event of internal jugular vein occlusion. A 21-gauge needle access with a 4-F two-part dilator (Micropuncture; Cook, Inc, Bloomington, Indiana) was used for all de novo access. The peel-away sheath was advanced over a stiff guide wire (Rosen; Cook, Inc; guide wire provided in TDC kit). Neither Trendelenburg position (most of our tables cannot assume this position) nor patient maneuvers such as humming or breath holding were used. Before the availability of aerostatic sheaths, when the dilator was removed from the peel-away sheath, the sheath was pinched just above the cutaneous insertion site while the TDC was passed into it (3). After aerostatic sheaths came into use, pinching was no longer performed. Every effort was made to "even up" the staggered tips of the TDC so that they pierced the aerostatic valve simultaneously in an effort to minimize any air entry.

As soon as the aerostatic sheath for TDCs became available, operating physicians adopted it. During the transition, the vendor provided extra sheaths so that procedures using old kits, which did not have the aerostatic sheath, could benefit from the new sheaths. Because of this, the point in time of complete transition to aerostatic sheath use was identified readily.

OTWE was performed over a single hydrophilic wire (Roadrunner Firm; Cook, Inc) using the weaving technique (9) except rarely a second wire was used if difficulty was encountered. This level of detail was not captured in any of the searched databases, and the exact percentage of OTWE done with a single wire versus two wires is unknown; however, the single-wire technique accounts for > 95% of OTWEs. During exchange, every effort was made to maintain aerostasis by compressing the tunnel entry site. During OTWE for TDC malfunction, fibrin sheath disruption was performed as previously described (10) using an occlusion balloon (Cook, Inc) moved back and forth to disrupt the sheath. If OTWE was for infection, fibrin sheath disruption was not performed unless there was concomitant TDC dysfunction. Tract recanalization was performed as previously described (11).

Management of AE depended on the clinical scenario. Asymptomatic air emboli identified during fluoroscopy did not prompt any intervention other than considering an increase in percentage of inspired oxygen the patient was receiving and careful monitoring. Symptomatic air emboli were generally managed with left lateral decubitus position, provided that the clinical scenario allowed (ie, no chest compressions).

AE events, once identified, were further investigated with chart review. These events were classified as "suspected" based on clinical symptoms or "confirmed" by audible air inspiration or fluoroscopic visualization.

Statistical Analysis

Statistical comparison of AE events from de novo TDC placement before and after the use of aerostatic sheaths and comparison of AE episodes based on venous access location were performed using Fisher exact test, which is a nonparametric test designed to assess the statistical association between two categorical variables. Statistical analysis was conducted with the use of SAS software with a P value < .05 considered statistically significant (SAS Component Language 9.3; SAS Institute, Cary, North Carolina).

RESULTS

During the study period, 5,789 consecutive TDCs were placed, including 3,963 de novo, 1,811 by OTWE, and 15 by tract recanalization. The transition to aerostatic sheaths occurred in July 2005, and the dataset was divided into procedures before aerostatic sheaths (ie, before July 2005) and procedures after aerostatic sheaths. During the 12-year study period, 15 patients (0.26%) experienced an AE event.

Detailed information regarding the AE episodes is provided in **Table 1**. The median age of patients was 55 years (range, 26–78 y). Of the 15 AE events, 13 were confirmed and 2 were suspected. Four patients were asymptomatic, three of whom received no treatment. The remaining asymptomatic patient received supplemental oxygen. Six patients had mild symptoms that