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Use of an ECG-based confirmatory technique for bedside placement of reverse-tunneled cuffed dialysis catheters in three morbidly obese patients

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We are currently in the midst of a worldwide obesity epidemic, including in patients with end-stage kidney disease. Placing hemodialysis catheters is a particular challenge in patients with extreme obesity. Here we describe the merging of two technologies to place catheters in patients who are too heavy (over 225 kg) to be placed safely on a procedure table for fluoroscopic guidance. The first technology is ECG-guided placement of catheters, well established for guidance of peripherally inserted central catheters (PICCs) and tunneled and nontunneled central venous catheters. The second is reverse-tunneling dialysis catheters, which allow precise placement of the tip of the catheter before creating the tunnel. We successfully placed catheters in three morbidly obese patients with acute kidney injury and followed them until their kidneys recovered and the catheters were removed. The catheters were placed in the patient's bed in a procedure room with subsequent confirmatory chest radiographs. Catheter performance based on blood flow rates was excellent and there were no complications. We suggest placement of ECG-guided tunneled hemodialysis catheters using a reversed-tunneling technique in those patients with extreme obesity who are too heavy to place on a fluoroscopy procedure table.

Kidney International (2015) **88,** 633–636; doi:10.1038/ki.2015.191; published online 8 July 2015

KEYWORDS: acute kidney injury; central venous catheters; ECG; hemodialysis; obesity; technical innovation

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Received 11 February 2015; revised 9 April 2015; accepted 30 April 2015; published online 8 July 2015

Central venous catheters (CVCs) are important for long-term venous access needed for performing chronic hemodialysis, delivering medications and fluids, drawing central venous blood, or measuring certain cardiovascular parameters. Although the correct catheter tip position for most catheters is disputed in the literature, most recommendations are for the tip location to be in the lower third of the superior vena cava (SVC) near the cavoatrial junction, and accurate positioning is critical to avoid complications.[1] The appropriate tip location for dialysis catheters, however, is clearly stated in the KDOQI (Kidney Dialysis Outcome Quality Initiative). Quoting from the Clinical Practice Guidelines: 'Long-term catheter systems—tunneled cuffed catheters (TCCs) and tunneled port catheter systems—should have their tips within the right atrium confirmed by fluoroscopy for optimal flow.'[2]

Complications arising from a tip location significantly proximal to the cavoatrial junction include fibrin sheath formation that can lead to catheter malfunction, deep venous thrombosus, and septic phlebitis and complications arising from tip locations distal to the cavoatrial junction including cardiac tamponade, arrhythmias, and tricuspid valve dysfunction.[1,2]

For long-term catheters, fluoroscopy is the widely accepted method for placement and positioning because of its ease of placement, accuracy, reliability, and relatively few complications.[3] When placing TCCs for long-term hemodialysis, fluoroscopy is recommended by the NKF KDOQI (National Kidney Foundation DOQI) in their 2006 Clinical Practice Guidelines and Recommendations for Vascular Access.[2] On the other hand, short-term catheters, such as peripherally inserted central catheters (PICCs), can be placed at the patient's bedside, and the standard confirmation method is a chest X-ray after placement with readjustments as necessary.[1]

Over the past 20 years, a new technique using electrocardiographic (ECG)-guided positioning of catheter tips has been gaining traction, particularly in Europe.[4] ECG-guided positioning is described as having the same accuracy as fluoroscopy while decreasing patient exposure to radiation as well as being less costly, more time efficient, easier to use, and more convenient.[5–7] ECG-guided positioning requires using

Table 1 | Summary of patients who had catheters placed using ECG guidance

Patient	Sex	Age	Weight (kg/BMI)	Diagnosis	Indication for dialysis	Treatment no./average blood flow (ml/min)	Dwell (days)
A	M	34	239/73.7	Lower extremity cellulitis	Acute kidney injury secondary to antibiotic-induced nephritis	3/383.3	34
B	M	63	238/71.1	Lower extremity cellulitis	Multifactorial acute kidney injury including (1) prerenal azotemia secondary to decreased intravascular volume from diuresis, (2) acute tubular necrosis in setting of above, and (3) acute interstitial nephritis/transient interstitial nephritis from multiple antibiotic exposure and proton pump inhibitor use	5/397.0	19
C	M	43	221.6/74.3	Pannuliculitis	Multifactorial acute kidney injury, likely bilateral cortical necrosis with acute tubular necrosis	9/345.7	21

Abbreviations: BMI, body mass index; M, male.

the catheter tip as an intravascular electrode, and this can be achieved by using either a metal guidewire or a column of saline in the catheter tip.[8] The use of ECG-guided positioning has been well documented for the placement of PICCs as well as other CVCs.[9–11] A popular device for locating the cavoatrial junction using an electrode in the catheter is called 'Sapiens' (Bard Medical, Salt Lake City, UT). However, its intended use is for the placement of PICCs, and it has not been described for the placement of a reverse-tunneled dialysis catheter. Here, we describe the use of the Bard Sapiens Tip Locator System for the placement of cuffed, tunneled dialysis catheters in three morbidly obese patients who exceeded the weight limit for our fluoroscopy tables.

RESULTS

All placements were technically successful with no immediate or long-term complications. There were no clotting episodes or infections, which is not surprising given the short dwell times. A summary of the three patients is included in Table 1. Postprocedure chest radiographs were obtained on each patient. Patient A had clear visualization of the tip of the catheter at the SVC/right atrium (RA) junction. The only other chest radiograph was obtained 21 days later (on the day of catheter removal) and this demonstrated no change in the position of the catheter (Figure 2). Patient B had clear visualization of the catheter tip at the SVC/RA junction on the immediate chest radiograph. No other chest radiographs were obtained before the catheter was removed. In patient C, the tip could not be seen despite multiple attempts because of limitations of the portable machine and the patient's body habitus. A subsequent chest radiograph 12 days later demonstrated the tip of the catheter to be in the RA.

The number of dialysis sessions and average blood flow achieved is reported in Table 1. Each session of dialysis was completed without complication using the catheters. The nephrology fellow and attending reviewed the need for dialysis at each treatment. Data included renal clearance, hyperkalemia, metabolic acidosis, edema, and other markers of kidney function. Dialysis was discontinued if the attending nephrologist determined it was no longer necessary based on clinical data collected and examination of the patient. Once this was achieved, the patient underwent bedside removal of the catheter. There were no complications related to catheter removal.

DISCUSSION

The world is in the midst of an obesity epidemic.[12] As our patients grow larger, we will be forced to come up with creative solutions to treat them. ECG-monitored central line placement provides accurate positioning of the tip of a catheter.[5,8,10,13] Reverse-tunnel dialysis catheters allow tip placement first before creating a tunnel.[14,15] This is the first known report of combining the two technologies to place a cuffed tunneled catheter at the bedside in morbidly obese patients. In Italy, there are several reports of using intra-cavitary ECG for positioning the tip of CVCs.[9,11] These articles assess the feasibility of intra-cavitary ECG and its ability to replace radiologic guidance for the placement of CVCs. As this is not our current standard of practice, this paper was more concerned with the use of intra-cavitary ECG and reverse-tunneled dialysis catheters in patients who had limited options for radiologic guidance. Our patients were able to safely receive a functional dialysis catheter until the return of renal function. If the patients did not have recovery of renal function, this catheter could have served as a bridge to a more permanent dialysis access such as an arm fistula or graft. Even though our patients did not keep a catheter for a long period of time, and could possibly have received a temporary dialysis catheter, this was not known at the onset of treatment and therefore saved the patient from at least one extra procedure. We prefer tunneled catheters over temporary catheters for acute kidney injury.[16]

There are known limitations with the ECG system, namely instances when the P-wave is unpredictable. This occurs in patients with a pacemaker and in atrial fibrillation. Fortunately, none of our patients had these limitations. Our study is limited with the number of patients and no valid comparisons could be drawn from the data collected. We cannot make any claims about the long-term safety of this procedure nor can we advocate our procedure over other methods for placement of a catheter in this population, such as moving the patient to a table with a safe weight limit and

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