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Laparoscopic *versus* open peritoneal dialysis catheter insertion cost analysis

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ABSTRACT

Background: Peritoneal dialysis (PD) is a cost-effective alternative to hemodialysis (HD). PD catheters have traditionally been inserted through a small open incision, but insertion using laparoscopic visualization has become increasingly popular and is associated with less catheter malfunction. The aim of this study was to compare costs of laparoscopic and open insertion strategies while taking into account postoperative complications and future salvage procedures.

Methods: A decision analysis model was constructed to simulate 1 y outcomes after PD catheter insertion by either the open or laparoscopic approach. Possible outcomes after PD catheter placement included functional catheter, infection, and catheter malfunction. Ultimately, patients continued with successful PD or switched to HD. Baseline probabilities, costs, and ranges were determined from a critical review of the literature. Sensitivity analyses were performed to determine the model strength over a range of clinically relevant probabilities.

Results: The total annual costs, including postoperative management and dialysis treatment, were $69,491 for laparoscopic insertion and $69,960 for open insertion. In case of a catheter malfunction, an initial attempt at salvage by fluoroscopy-guided wire manipulation cost less than a first attempt by laparoscopic repositioning.

Conclusions: When accounting for a year of postoperative management and treatment, laparoscopic insertion can be less costly than open insertion in the hands of an experienced surgeon. Despite higher initial costs, PD catheter insertion under laparoscopic visualization can have lower total costs due to fewer postoperative complications. With increasing emphasis on cost-effective care, laparoscopic insertion is a valuable tool for initiating PD.

1. Introduction

The United States has >500,000 cases of end-stage renal disease (ESRD) [1]. The treatment of choice for ESRD is kidney transplantation; however, the number of potential recipients far exceeds the number of available organs. Dialysis is the preferred treatment alternative for renal replacement therapy. Although hemodialysis (HD) is the most popular form of dialysis, peritoneal dialysis (PD) is a valuable option for high-functioning patients to perform dialysis in the home. When compared with HD, PD can improve the quality of life for patients by reducing trips to the hospital and has demonstrated

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cost savings for the health care system [2,3]. Seven percent of the U.S. dialysis population uses PD, with >26,000 ESRD patients currently on PD and >6000 new patients initiating PD each year [1]. Internationally, PD is used by a greater proportion of ESRD patients than in the United States [4].

Successful dialysis treatment requires free dialysis inflow and outflow through an inserted catheter [5]. Major complications of PD treatment include outflow obstruction and catheter-related infection [6]. These complications can lead to PD technique failure and switch to HD. High rates of technique failure are cited as a main factor limiting the use of PD [7].

Surgical placement of a PD catheter can be performed by either open mini-laparotomy or by a laparoscopic approach. The open technique entails making a small incision and inserting the catheter with limited visualization into the peritoneal cavity. The most commonly stated advantages of laparoscopic catheter insertion are better visualization of the implantation site and the ability to combine catheter insertion with other procedures such as omentectomy and hernia repair [8]. Better visualization can lead to superior catheter placement and fewer flow obstructions, thus reducing the number of costly interventions needed to maintain catheter function. Open and laparoscopic insertion techniques have been compared in several trials, but wide variations in rates of infection and catheter malfunction have been reported [9–13]. Laparoscopic insertion has higher initial costs than the open procedure but ultimately may result in cost savings due to fewer procedures required to salvage catheter function and fewer patients switching to the more expensive hemodialysis [14]. The expense of laparoscopic technology has led some surgeons to question the use of the laparoscopic technique for PD catheter insertion. A decision analysis model was developed to determine the least costly insertion strategy over a wide range of complication rates and treatment costs when considering a year of postoperative management and treatment.

2. Materials and methods

2.1. The model

A decision analysis model was developed to compare laparoscopic and open PD catheter insertion techniques. Decision analysis is a quantitative technique, which allows synthesis of data from several sources to evaluate therapeutic alternatives [15]. The computer-based decision model was designed using TreeAge Pro 2012 to display paths leading to each treatment outcome and perform computations for cost minimization analyses and sensitivity analyses [16]. In a decision analysis model, hypothetical patients are run through a model or decision tree and their outcomes are determined by probabilities from a literature analysis. The cost of each strategy is determined by the outcomes of these patients at 1 year. A critical literature search was conducted to determine the baseline values and ranges of clinically meaningful probabilities and costs at each node according to available literature. Finally, a sensitivity analysis is performed by ranging variables to clinically meaningful values to account for variability in clinical practice. This method is consistent with previous cost analyses [17].

2.2. Decision analysis tree

The tree begins with a decision by the surgeon to insert a PD catheter by open or laparoscopic technique (Fig. 1). After this initial decision, the possible outcomes are functional catheter, infection, or catheter malfunction. Terminal states are the two different final outcomes that patients could have at the end of 1 y. All patients must reach a terminal state at the conclusion of the model. In this model, the terminal states were (1) successful PD treatment after 1 y or (2) dialysis modality switch to HD. Mortality was not included in this model because no significant difference in survival has been found between patients using HD and PD or different methods of PD insertion [18].

Catheter malfunction is defined as poor outflow and/or inflow of dialysate fluid, and failure to initiate or continue PD treatment after standard treatments, such as flushing, have been attempted to restore dialysate flow [19]. In this model, infection is defined as peritonitis with an effluent white blood cell count of at least 100/μL with ≥50% polymorphonuclear cells [20]. Patients with peritonitis undergo antibiotic treatment and hospital admission. These patients enter a terminal outcome of successful treatment of infection with functional catheter or unsuccessful treatment with removal of catheter and switch to HD. Patients with functional catheters without complications enter terminal outcomes of successful PD or elective transfer to HD due to intolerance of PD treatments.

For patients with malfunctioning catheters, two strategies were considered to restore catheter function. Guide wire repositioning by fluoroscopy involves the use of radiographic imaging with contrast fluid to locate the catheter followed by the insertion of a guide wire into the catheter to correct the catheter position and restore dialysate flow. Laparoscopic rescue requires a return to the operating room to use laparoscopic instruments to reposition and restore catheter function. In the first strategy, patients with malfunctioning catheters underwent guide wire repositioning followed by an attempt at laparoscopic rescue if dialysis function was not restored. In the second strategy, patients immediately underwent a laparoscopic salvage attempt. In both strategies, patients who failed to have successful restoration of function by laparoscopic salvage entered the terminal outcome of switch to HD.

2.3. Probabilities

Table 1 summarizes the probabilities and ranges of outcomes, costs, and complications used in the decision analysis model. These values are based on a review of the available literature comparing open and laparoscopic PD catheter insertion, examining PD catheter rescue procedures, or reporting treatment costs of dialysis and PD complications. MEDLINE was systematically searched for all articles dating from 1995 to present comparing open and laparoscopic PD catheter insertion. For infection and malfunction rates, only studies comparing open and laparoscopic insertion were considered. Baseline values were determined by a fixed weight average of included studies [31]. For example, the base estimate of malfunction rates for laparoscopic and open insertions were fixed