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Complications of Continuous Ambulatory Peritoneal Dialysis (CADP) catheter placement in pediatric patients

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Abstract: **CAPD is a peritoneal dialysis (PD) technique introduced in 1978 as a renal replacement therapy more often in children, whenever high-level centers are available. It represents a typical treatment for end-stage kidney disease and can be inserted as a bedside procedure (Cook Medical, Bloomington) or operatively under general anesthesia (Tenckhoff catheter). Complications associated with catheter placement are well-known and have been extensively studied. Multiple factors influence catheter survival and functions, including the shape of the subcutaneous segment, the number of cuffs, and the design of the intraperitoneal part. Comprehensive research was conducted to study the outcomes of the straight and coiled-tip catheters. A pooled dataset produced by a systematic review and meta-analysis of 13 randomized controlled trials examined catheter survival, blockage, migration, leakage, exit site infection, hernia, intestinal obstruction, peritonitis, and catheter removal, favoring a surgically inserted, straight-tip catheter [2]. In our study, we included 74 cases of children under 18 with end-stage renal disease (ESRD) from different hospitals in the Najaf Directorate of Health (NDoH) between July 2022 and July 2025. Both designs have been used according to the age of patients (straight-tip double cuff catheter used in infants, while the coiled-tip CAPD catheter was inserted in older age group patients). 72 (98%) had a CAPD coil-tip catheter inserted operatively. This study aims to investigate the complications associated with CAPD catheters in our center and to examine the factors contributing to failure, survival, and removal. We concluded that peritonitis is the commonly reported complication over the follow-up period, followed by CAPD obstruction and exit site infection.**

Keywords: **ESRD, CAPD, chronic kidney disease in children.**

1. INTRODUCTION

The incidence of ESRD is increasing in the pediatric age group. The US Data System and the North America Pediatric Renal Transplant Cooperative Study estimated that 5000 children under 20 years and 200 children under 2 years are diagnosed with ESRD annually [3]. PD is a model of RRT that was first introduced in 1978 and has gained more popularity

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and acceptance due to its effectiveness, safety, well-tolerance, and the need for minimal training, allowing the child to lead a relatively normal life and development [3,4]. It doesn't require inpatient care or a frequent clinic visit; rather, it can be cared for at home with minimal training [3].

Nevertheless, the procedure has well-known and extensively studied complications broadly classified as early and late or infectious and non-infectious [3]. Additionally, the literature demonstrates that PD catheter-related complications and failure are largely attributed to the catheter's shape and the placement technique, with a favorable outcome toward the straight-tip and surgical insertion [2]. In our study, we included 74 children with ESRD. Of whom, 98% (72) had a laparoscopically inserted, coil-tip catheter with promising results.

This research paper aims to compare the outcome of our experience in NDoH with the international studies and analyze factors attributed to survival, failure, conversion, or removal of CAPD.

Patients' characteristics

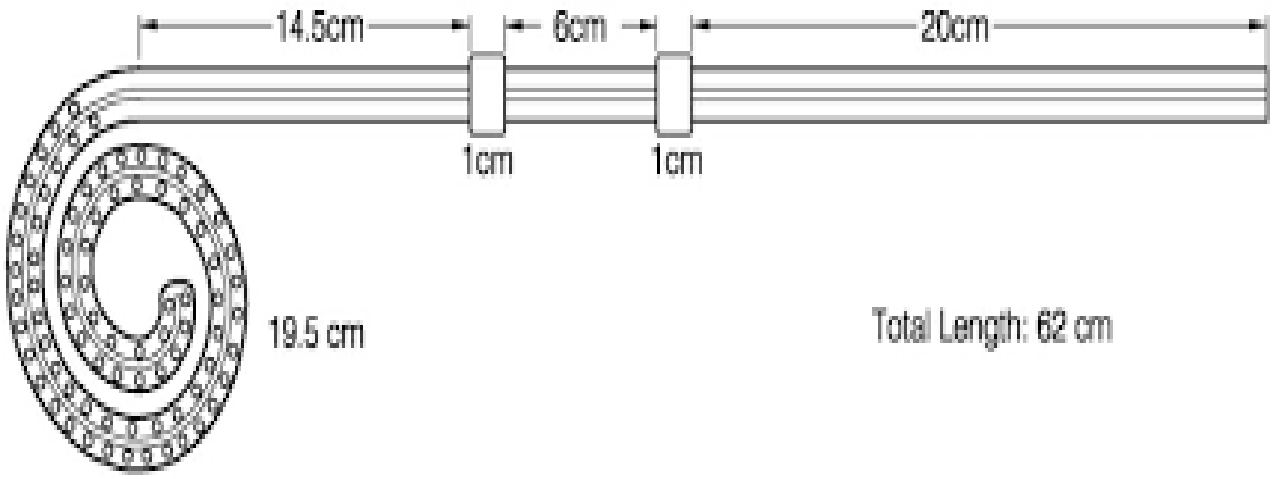
Seventy-four ESRD children were included in the study, with 24 being males and 50 being females (male-to-female ratio was 2:3). The age range was from 18 months to 96 months. Congenital anomalies involving the urinary tract (posterior urethral valve) have been identified as a leading cause of ESRD (16) in our center. Followed by chronic glomerulonephritis (12), nephrotic syndrome (8), anogenital malformation (8), polycystic kidney disease (4), diabetes mellitus (4), and spinal malformation (2).

Exclusion criteria

Patients with liver disease and ascites, local skin infection, bleeding diathesis, and unrepaired ventral hernia are considered unsuitable for CAPD insertion.

2. METHODOLOGY AND MATERIALS

74 under-18-year-olds with ESRD have been selected, treated with a laparoscopically inserted Tenckhoff, double-cuffed CAPD catheter, and evaluated over 1-4 years in our center. The patient's medical reports have been reviewed retrospectively to study risk factors associated with ESRD, current treatment modalities, and surgical history. Additionally, evaluation of cases spanning 1-4 years was conducted by a multidisciplinary team, comprising a pediatric surgeon, a nephrologist, a pediatrician, a trained nurse, and a psychologist. After receiving the patient in the pediatric surgical department, the proper design, size, and site are discussed with the child and healthcare providers, considering the body habitus and presence of previous abdominal scars or surgeries. Medical records are kept in dialysis centers available at tertiary hospitals.



Coil-tip, double cuff Tenckhoff catheter

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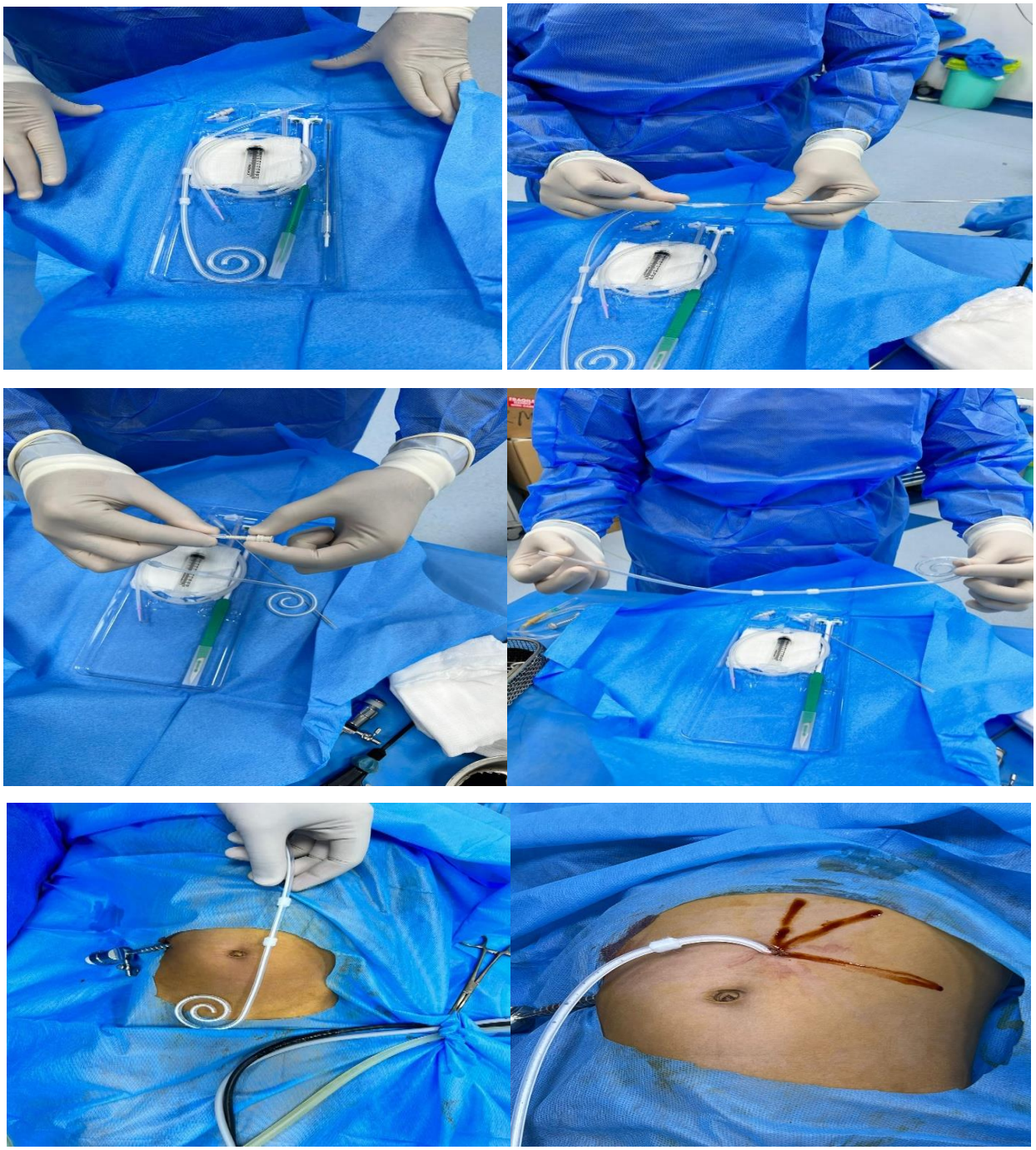

Doubled cuffed, coil-tip, Tenckhoff catheter

Surgical procedure:

In an upright position, measuring the length of the catheter extending from the symphysis pubis to an inch above the umbilicus and marking the insertion and existing sites is determined preoperatively. Under general anesthesia, an induction dose of Antibiotic is administered, and preparation of the abdominal wall from the nipple to mid-thigh using povidone iodine is implemented. A 1cm supraumbilical, paramidline incision is created using a surgical blade available in the CAPD kit. Pneumoperitoneum was installed by a Veress needle or via the dialysis catheter (if not occluded) or by open technique, with intra-abdominal pressure of 8-12 mmHg according to the patient's age. The 5 mm or 10 mm port is inserted right subcostal midclavicular line for the camera (occasionally we need to insert a second operative 5 mm port to be placed in RIF for proper access).

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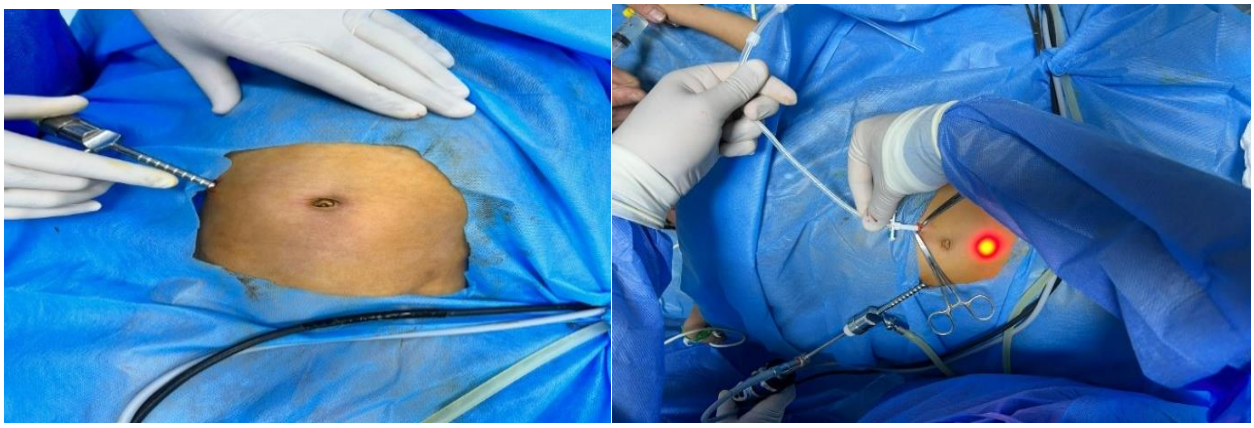
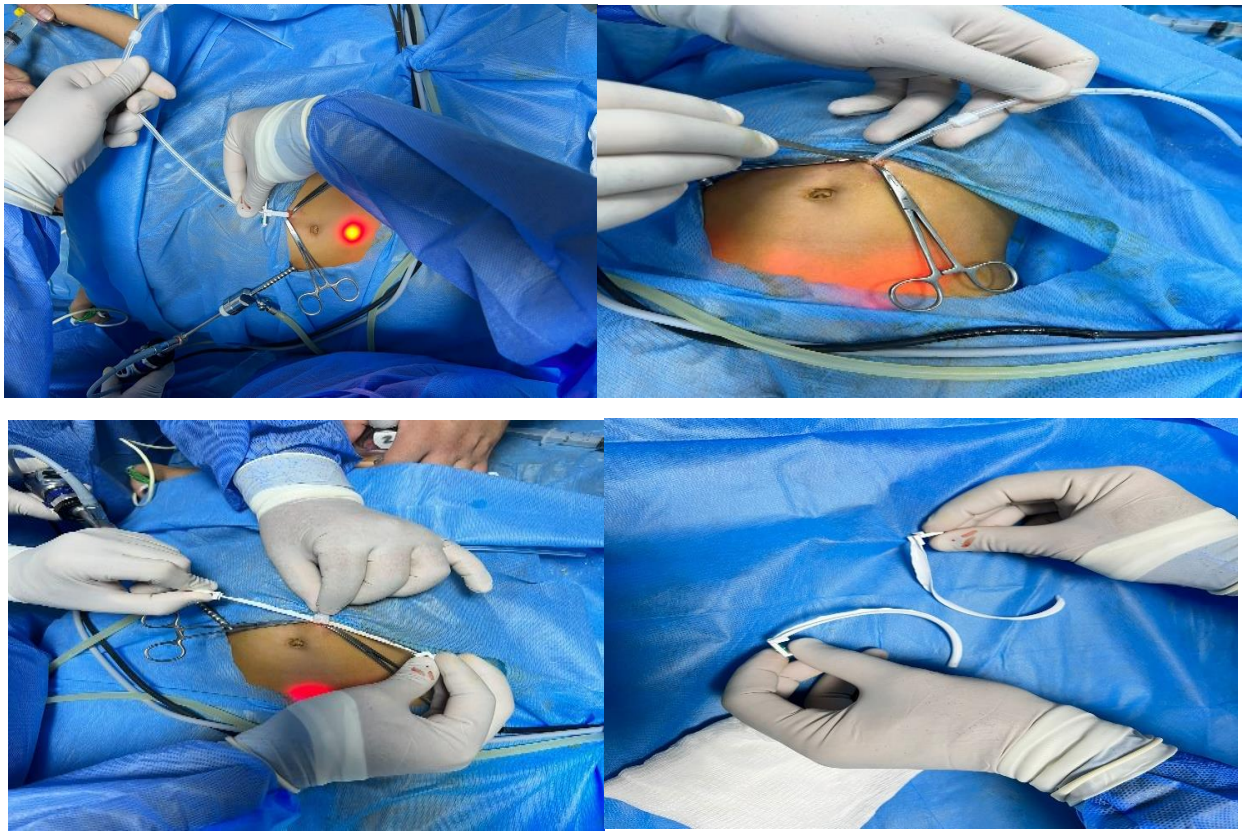
The tip of the tube slides gently through the anterior and posterior rectus sheaths, intervening the rectus muscle until approaching the mark defined earlier. By reaching the peritoneum caudal to the arcuate line of Douglas, the catheter is grasped using laparoscopic graspers to reside in the pelvis near the top of the bladder, posterior to the symphysis pubis. If the omentum extends to the pelvis (uncommon), the distal omentum is moved cephalad and fixed to the anterior abdominal wall (omentopexy). The proximal end is tunneled through the fatty tissue 2-3 cm before exiting the skin on the right side of the abdomen. The patency is checked, and the existing site is to begin pointed laterally. No skin stitch is used. Then, the peritoneal cavity is deflated and carbon dioxide is allowed to leak, ports are retrieved, and a dressing is applied. PD can be safely commenced after 8-12 hours. Oral feeding was allowed after a clinically confirmed bowel movement. Discharge home usually 24-48 hours with 2-3 days of injectable antibiotics. No intraoperative complications, and the overall time required for the procedure is 30 minutes. Postoperative pain is well-controlled by intravenous analgesia (acetaminophen). In 20 children straight Tenckhoff catheter was used, in 17 patients, coil catheters were used, but all catheters were double-cuff.



Steps of laparoscopic placement of the CAPD



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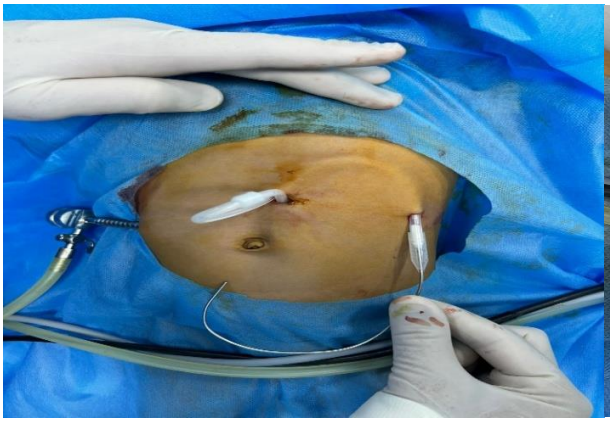

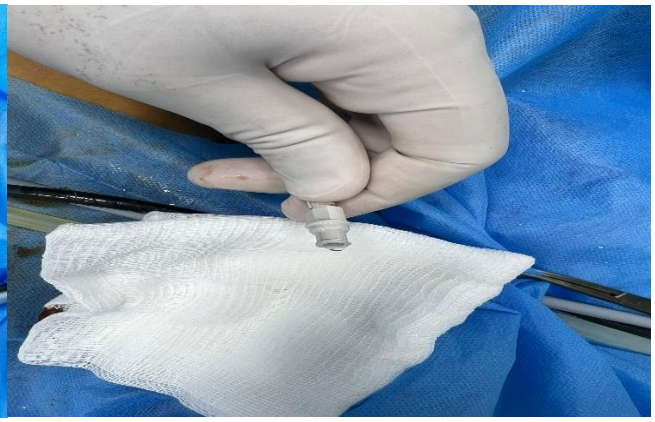

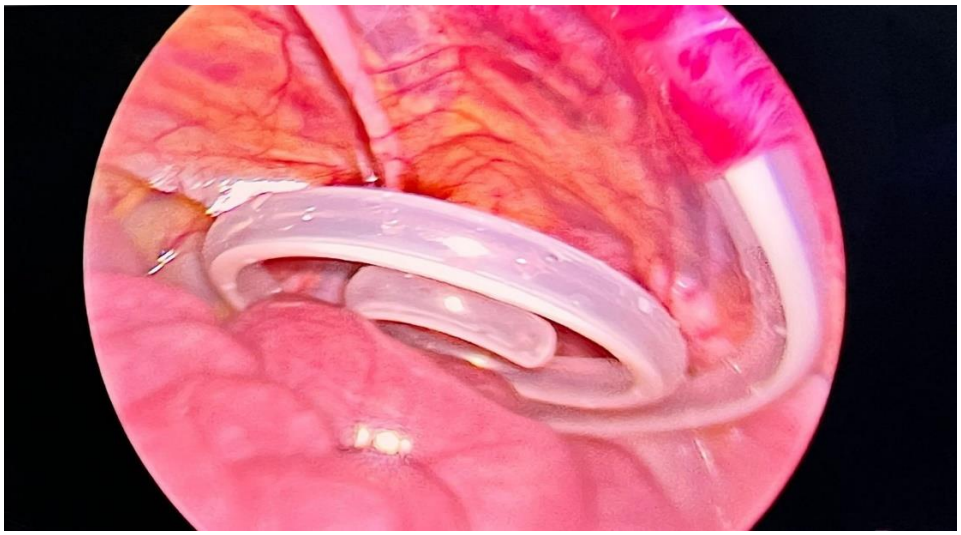

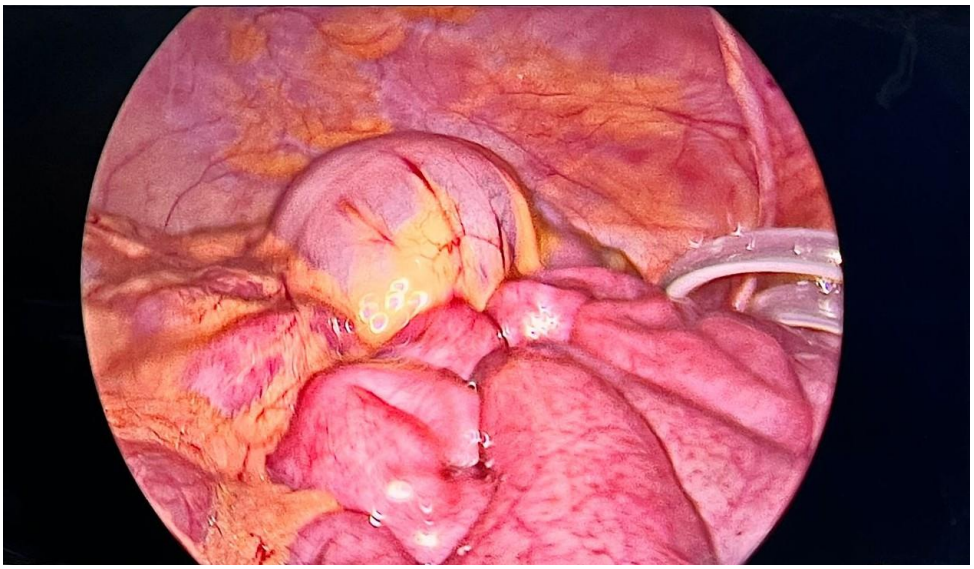

3. RESULT

74 patients had successful laparoscopic CAPD placement. Throughout the evaluation period, patients were primarily presented with infectious complications, such as fever, vomiting, exit-site infection, and peritonitis. Non-infectious complications have been reported less frequently. Eleven out of 74 patients (15%) presented with peritonitis, and seven (10%) presented with exit-site infection.

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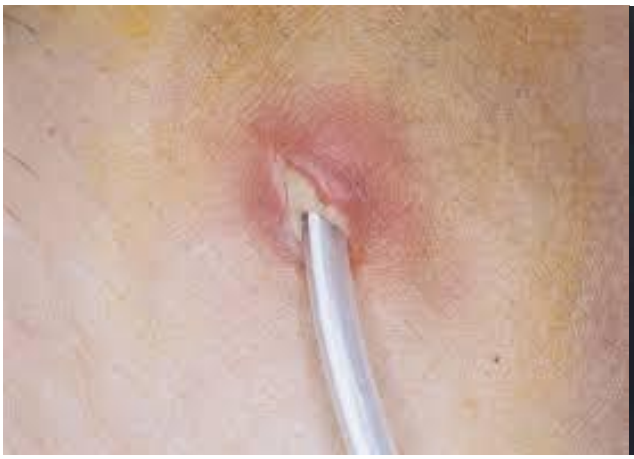
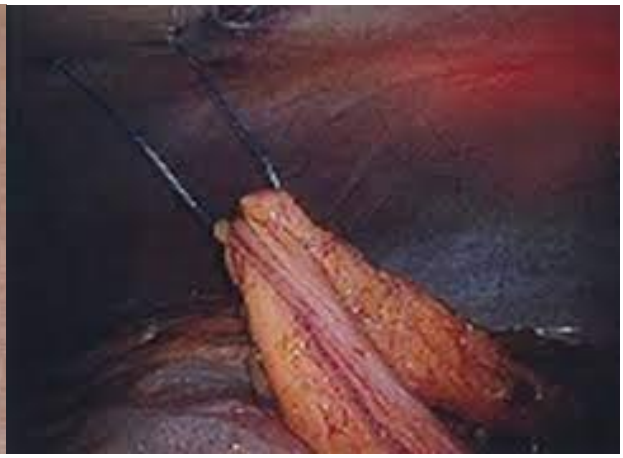
Twenty-four patients (32%) from the cohort group experienced varying degrees of catheter malfunction. 8 cases (10%) presented with CAPD catheter obstruction, two of them had intraluminal and 6 extraluminal blockage. 3 patients developed an umbilical hernia, and an additional three experienced a right-sided inguinal hernia. 35 patients (47%) underwent omentectomy due to a long omentum extending to the pelvis. Five cases of them (6%) were complicated by intraabdominal hemorrhage that stopped spontaneously. 5 (6%) omentopexies were performed uneventfully due to redundant omentum. The remaining cases had short omenta that extended away from the CAPD insertion site. One case of intra-abdominal hemorrhage caused by superficial liver injury healed spontaneously. 5 (6%) cases required a change from peritoneal to hemodialysis. 3 cases died in the immediate post-operative period owing to medical-related complications. No catheter tip migration was reported throughout the evaluation period. Metabolic complications are typically managed medically without the need for surgical intervention. The table below shows the percentage of complications:

Table 1: Percentage of CAPD catheter insertion

CAPD complications	Number of cases	Percentage
Peritonitis	11	26%
Catheter obstruction	8	10%
Hernia	8	10%
Exit site infection	7	10%
Hemorrhage	5	6%
Conversion to hemodialysis	5	6%
Death	3	4%
Catheter tip migration	0	0%



Exit site infection



Omentopexy

4. DISCUSSION

Complications of CAPD have been broadly classified into infectious, non-infectious, and metabolic. In our study, we found that contagious complications are largely reported within the first 1-4 years of follow-up. Infectious complications include fever, vomiting, infection of the exit site, and peritonitis. Eleven out of 74 patients (15%) presented with signs and symptoms of peritonitis. CAPD-related peritonitis is an inflammation of the peritoneum of secondary type resulting from an indwelling dialysis catheter [1]. It is polymicrobial in origin and manifests as poor feeding, lethargy, vomiting, abdominal pain, and distension [1]. Signs include febrile attacks, chills and rigors, cloudy peritoneal fluid, abdominal tenderness and rebound tenderness, and elevated white blood cell counts. Six out of the 11 patients (50%) presented with recurrent intestinal obstructions due to adhesion, and one case experienced frozen abdomen/pelvis as a result of recurrent peritonitis. For the diagnosis of peritonitis, it is recommended that two or more features are present:

1. Signs and symptoms consistent with peritonitis include abdominal pain, cloudy dialysis fluid.
2. White cell count of the dialysis effluent of more than 0.1 * 10^9/L (after 2 hours dwelling time), or > 50% polymorphonuclear leukocytosis [6].
3. Positive culture of the dialysis fluid.

Infection can be transmitted through intraluminal, extraluminal, transmural, hematogenous, and transvaginal. Treatment includes a combination of surgical removal of the source of infection (CAPD), adhesiolysis, and intraperitoneal antibiotics. Conversion into hemodialysis might be initiated (2 cases due to recurrent peritonitis).

Seven cases (10%) in the study group presented with exit-site infection. Exit site infection (with or without tunnel infection) is defined as "*the presence of purulent discharge, with or without erythema of the skin at the catheter-epidermal interface"* [7]. It represents a diagnostic challenge, as an allergic skin reaction immediately following CAPD placement might be observed frequently. Therefore, an absence of purulent discharge, tenderness, induration, and Ultrasound evidence of fluid collection makes the diagnosis of exit site infection uncertain. represents a vital diagnostic criterion [7]. Diphtheriodes, Staphylococcus aureus, Pseudomonas aeruginosa, and fungi are the main isolated organisms in descending order of frequency [7]. Treatment consists of topical application of gentamycin or mupirocin at the exit site.

Non-infectious complications include catheter obstruction, intra-abdominal bleeding, hernia, catheter removal, and death. 8 cases (10%) in the cohort study presented with CAPD catheter obstruction, two of them had intraluminal and 6 extraluminal blockage. Intraluminal catheter obstruction resulted from either a piece of omentum or a blood clot. Extraluminal CAPD obstruction caused by omentum wrap, kinking of the catheter, band, or adhesion. Treatment is by surgical release, adhesiolysis, recanalization (using normal saline flushing, heparin solution), omentectomy (for long omentum extended to the pelvic cavity), and omentopexy. 3 cases required CAPD removal and initiation of hemodialysis.

3 patients developed an umbilical hernia, and another three experienced a right-sided inguinal type. An increase in intrabdominal pressure owing to dialysate miscalculation is the likely cause. All of them were corrected surgically after stabilization of the patient's medical condition.

Five cases (6%) were complicated by intraabdominal bleeding, 4 of them following omentectomy for redundant omentum, and the remaining case caused by superficial liver injury. All of them stopped spontaneously. No other organ damage or injury to the inferior epigastric vessel was reported.

3 cases of death happened in the immediate post-operative period owing to medical-related complications. No catheter tip migration was reported throughout the evaluation period. Metabolic complications are managed medically without surgical intervention.

Peritoneal dialysis (PD) catheter exit-site infections are a known complication, and the management often involves topical treatments such as Hydrocortisone Gel [8]

5. CONCLUSION

We concluded that Laparoscopic placement of the CAPD catheter is a safe, well-tolerated, and effective procedure. Patients with an ambulatory peritoneal catheter can lead a relatively normal life and development with minimum training.

Complications of the CAPD are classified as infectious and non-infectious. Our study found that infectious complications (peritonitis) are primarily encountered throughout the follow-up period. Followed in order of frequency by catheter blockage and exit site infection. Other non-infectious complications include hernia, intestinal obstruction, and intra-abdominal bleeding. Omentectomy was identified as a risk factor for intraabdominal bleeding.

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