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Analysis of complications related to dialysis catheters in cancer patients

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Abstract

Background: Data on renal replacement therapy (RRT) in cancer patients with acute kidney injury (AKI) in the intensive care unit (ICU) and how these factors influence the efficiency of dialysis and the outcomes of these patients are scarce. We aim to describe the predictive clinical characteristics of hemodialysis catheter-related complications in critically ill cancer patients with acute kidney injury.

Methods: This is a retrospective cohort study of 62 cancer patients subjected to short-term hemodialysis catheter implants. We evaluated the clinical characteristics of patients and the complications related to catheter implantation: mild malfunction, characterized by reversal of access lines; infections; and catheter replacement due to severe malfunction or infections. The outcomes analyzed were recovery of renal function, discharge from the ICU, and death.

Results: The most frequent complications were related to mild malfunction, which justified dialysis line reversal in 21.3% of the patients. The complication rate was higher in patients undergoing conventional hemodialysis, in those with coronary disease, and in those who had more than three dialysis sessions. The presence of metastasis was more frequently related to catheter reversals. Patients with mild or severe malfunction were more likely to be hospitalized for more than 18 days in the ICU. All patients with mild malfunction had hospitalization times greater than 28 days.

Conclusions: Hemodialysis catheter-related complications were associated with longer ICU and hospital stays in cancer patients with AKI. Mild malfunction of the hemodialysis catheter was the most frequent complication. Patients with metastasis and sepsis, who used diuretics, and who used intermittent dialysis methods had milder catheter malfunctions.

Keywords: Renal insufficiency, Dialysis, Cancer care facilities, Catheters

Background

Acute kidney injury (AKI) is a common complication in cancer patients and may occur as a consequence of the underlying disease or treatment-related complications, such as tumor lysis syndrome [1] and drug-induced nephropathy [2], and may be secondary to surgical procedures [3]. In addition, one of the main etiologies of AKI in cancer patients is sepsis, which induces renal hypoperfusion secondary to systemic vasodilation and renal vasoconstriction [4].

Data on renal replacement therapy (RRT) in cancer patients with acute kidney injury (AKI) in the intensive care unit (ICU) are scarce, and intermittent hemodialysis complications such as hypotension and clotting are common in some studies. For example, in one study, hypotension occurred in 25% of the sessions, clotting in 23.8%, and malfunctioning catheters in 29.2% of the procedures [5]. The clinical manifestations of these dysfunctions are usually absent or reduced blood flow, negative arterial pressure in the extracorporeal system, and collapse of the arterial segment of the extracorporeal

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system. The reversal of dialysis blood lines is a procedure used when the blood flow during hemodialysis is low or when venous or arterial bloodline pressures are high. Although it is not a direct complication, dialysis blood line reversal represents a mild malfunction of the catheter that does not interrupt the procedure. Severe malfunction is characterized by the absence of blood flow in the extracorporeal system and the mild malfunction with a reversal of lines. Most catheters inserted into central veins develop fibrin clots one to several weeks after implantation and are silent at first, until they obstruct the distal part of the catheter; this clot development can be minimized by the conventional use of a heparin lock to prevent access thrombosis between hemodialysis sessions [6].

The objective of this study was to describe the clinical characteristics of hemodialysis catheter-related complications due to mild or severe malfunction of the access and infection in critically ill cancer patients with AKI and to evaluate the influence of clinical characteristics associated with the underlying oncological disease and other chronic comorbidities on the progression of these dialysis patients with complications related to the use of the dialysis catheter.

Methods

This was a retrospective cohort study based on a review of medical records, which evaluated the 62 patients who underwent vascular access implantation for hemodialysis at the AC Camargo Cancer Center from January 2011 to December 2013. The study included patients older than 18 years, with cancer that had been treated or was under treatment at the hospital, who presented AKI as defined in the KDIGO Guidelines for AKI [7] as stage 3, i.e., having an increase in serum creatinine greater than 300% (> 3×) relative to baseline or greater than or equal to 4 mg/dL, with an acute increase of at least 0.5 mg/dL, and a urinary flow of less than 0.3 ml/kg/h for 24 h or anuria in 12 h. All patients had indications for dialysis by the nephrology team who cared for them and underwent temporary catheter implantation for hemodialysis at admission. The catheters were all 20 cm/12 Fr (Arrow International, Inc.). Patients who did not have cancer, those who had long-term hemodialysis catheters, and those who did not undergo access implantation within the hospital were excluded from the study.

The electronic file system of the AC Camargo Cancer Center was used to locate the sample by observing the item "vascular access implantation for hemodialysis" in all patients with dialytic renal dysfunction admitted to the ICU within a 2-year period, followed by subsequent searches of the clinical and laboratory data of these patients. Data were collected after submission of the study protocol to the hospital's Ethics and Research Commission. The study was registered under number CAAE 32913714.3.0000.5432.

The demographic characteristics of the patients, such as age and gender; the clinical characteristics of the underlying neoplasia (type of neoplasia, whether solid or hematologic, and the presence of metastases); the type of treatment instituted (surgery, chemotherapy, radiotherapy); the performance status evaluated by the Zubrod scale (Eastern Cooperative Oncology Group, ECOG) [8]; previous comorbidities, such as systemic arterial hypertension (SAH), diabetes mellitus, congestive heart failure, and coronary disease; the AKI etiology (sepsis, nephrotoxicity, obstructive, multifactorial); the factors related to the access implantation for dialysis, such as the site (jugular, femoral) and insertion side; and the type of dialysis, such as conventional hemodialysis, extended or sustained low-efficiency dialysis (SLED), and continuous venovenous hemodiafiltration, were evaluated. The complications evaluated in this study related to catheter implantation were mild malfunction of catheter, characterized by reversal of access lines during dialysis that did not interrupt the procedure; infections; and catheter replacement due to severe malfunction of the catheter or infections. The outcomes analyzed were recovery of renal function, discharge from the ICU, and death.

The Statistical Package for the Social Sciences (SPSS) version 15.0 for Windows (SPSS Inc., Chicago, IL, USA) was used. Qualitative variables are presented as absolute (n) and relative (%) frequencies and quantitative variables as means and standard deviations. The presence of associations between discharge or death and other categorical variables was assessed using the chi-squared test and, when necessary, the chi-squared test of the likelihood ratio. The level of significance adopted was 0.05 (α=5%); descriptive levels (p) below this value were considered significant.

Results

Patient characteristics

The electronic records of 62 cancer patients hospitalized in the ICU with a diagnosis of AKI undergoing dialysis treatment were analyzed. The mean age of the patients was 63.9 ± 13.7 years, and 59.7% were male and 40.3% female. Solid tumors were the most frequent type of neoplasia (83.9%), and only 16.1% of the patients had hematologic diseases. In addition, 53.2% of the patients had at least one metastasis. Most of the patients (82%) had other morbidities, with SAH (41.9%) being the most prevalent. When classified according to ECOG, 7 (11.3%) patients belonged to ECOG 0, 28 (45.2%) to ECOG 1, 13 (20.9%) to ECOG 2, 12 (19.4%) to ECOG 3, 2 (3.2%) to ECOG 4, and none to ECOG 5. Regarding the oncological treatment modalities instituted, surgery

(74.1%) was the most used therapeutic resource. These data are listed in Table 1.

It was observed that 61.3% of the patients required mechanical ventilation ($n = 38$) and that sepsis occurred in 32.2% of the patients ($n = 20$). Among the dialysis therapies used for the treatment of AKI, the use of intermittent methods was more frequent, with conventional hemodialysis ($n = 41$, 67.2%) being the most frequently performed modality (Table 1).

The mean length of ICU stay was 15.5 ± 11.5 days, and the mean length of hospital stay was 44.0 ± 34.6 days. The mean permanence time of the hemodialysis catheter in the study patients was 18 days. The most frequent complications were related to mild malfunction, which justified dialysis line reversal in 21.3% of the patients. These data are listed in Table 2.

Influence of clinical characteristics and complications on the vascular access

Analysis of the access complications showed that mild malfunction was the most frequent, occurring in 13 patients (21.3%). The presence of metastasis was more frequently associated with catheter reversal (31.3% in patients with metastasis vs 10.3% in patients with no metastasis, $p < 0.05$), and these reversals were proportional to the number of metastases. In addition, the complication rate was higher in patients undergoing conventional hemodialysis (29.3% vs 5%). The risk of mild malfunction was higher in patients who had coronary artery disease (57.1% vs 16.7%) and who underwent more than three dialysis sessions. Septic patients had more dialysis mild malfunction (5%). It should be emphasized that the site of access implantation had no influence on line reversals. In addition, the use of diuretics after onset of AKI was a factor that contributed to an increase in dialysis catheter line reversals.

The catheter was replaced in 10 patients (16.7%), all of whom were older than 60 years, had ECOG status 3, were on mechanical ventilation for more than 2 days, and had more than three metastases. Those patients who needed catheter replacement due to severe malfunction included two implanted in the right femoral vein, one with hematologic disease, and one with a metastatic solid tumor. Only one patient needed catheter replacement due to infection. This patient had hematologic disease and associated coronary disease and was implanted in the right femoral vein. Due to the rarity of infection-related complications (one event) and catheter malfunction (two events), it was not possible to analyze their predictors. The other cases of catheter replacement occurred due to replacement for a tunneled catheter in five patients and due to accidental exteriorization in two. None of the 19 patients who progressed to palliative care needed the dialysis catheter replaced (Table 3).

We next compared the need for catheter line reversal and replacement between the groups of patients with ≤3

Table 1 Demographic and clinical characteristics of cancer patients with AKI admitted to the ICU

Characteristics	n	%
Male	37	59.7
Female	25	40.3
Performance status		
ECOG 3	12	19.3
Baseline neoplasia		
Solid tumor	52	83.9
Hematologic disease	10	16.1
Presence of metastasis	33	53.2
Cause of AKI		
Sepsis AKI	45	72.5
Sepsis + Nephrotoxicity AKI	4	6.4
Nephrotoxicity AKI	1	1.6
Use of diuretics	5	8.1
Dialysis		
Conventional HD	41	66.1
SLED	37	60.7
Continuous HD	12	19.7
Clinical progression		
ICU discharge	33	53.2
ICU death	29	46.8
Renal function recovery	24	42.8
Palliative care	20	32.2

HD hemodialysis, *ECOG* Eastern Cooperative Oncology Group, *ICU* intensive care unit, *SLED* sustained low-efficiency dialysis

Table 2 Sites of dialysis catheter insertion and frequencies of access-related complications in cancer patients with AKI

Variable	n	%
Insertion site		
Jugular	26	42.6
Right jugular	14	22.9
Left jugular	12	19.6
Femoral	26	42.6
Right femoral	15	24.5
Left femoral	11	18.0
Events/Complications		
Dialysis line reversal	13	21.3
HD catheter replacement	10	16.4
No. of sessions with same catheter	18	29.5
≤ 2	10	16.4
Between 3 and 7	23	44.3
≥ 8	8	13.1

AKI acute kidney injury, *HD* hemodialysis

Table 3 Need for catheter line reversal due mild malfunction of catheter during hemodialysis in cancer patients with AKI in the ICU

Clinical parameters	No reversal		With reversal		
	n	%	n	%	p
Metastasis	3	9.09	10	31.3	0.046*
Comorbidities					
SAH	22	84.6	4	15.4	0.330
DM	12	92.3	1	7.70	0.176
CHF	6	60.0	4	44.4	0.066
CKD	12	85.7	2	14.3	0.465
AMI/Coronary insufficiency	3	42.8	4	57.1	0.014*
Stroke	3	100	0	0.00	0.454
Treatment performed					
Surgery	32	74.4	11	26.2	0.308
Radiotherapy	7	70.0	3	30.0	0.521
Chemotherapy	14	73.6	5	27.8	0.425
Use of diuretics	2	40.0	3	75.0	0.007*
Clinical complications					
Sepsis	19	95.0	1	5	0.030*
Respiratory insufficiency	13	86.6	2	14.3	0.465
Delirium	1	50.0	1	50.0	0.314
MV	30	78.9	8	21.1	0.949
Dialysis mode					
Conventional HD	29	70.7	12	29.3	0.030*
SLED	27	72.9	10	27.0	0.176
Continuous HD	9	75.0	3	25.0	0.728
Clinical progression					
ICU death	25	86.2	4	13.8	0.172
Renal function recovery	19	79.1	5	20.8	0.925
ICU discharge	23	71.8	9	28.1	0.158
Palliative care	15	75.0	5	26.3	0.521

AKI acute kidney injury, *AMI* acute myocardial infarction, *CHF* congestive heart failure, *CKD* chronic kidney disease, *DM* diabetes mellitus, *ECOG* Eastern Cooperative Oncology Group, *HD* hemodialysis, *SAH* systemic arterial hypertension, *SLED* sustained low-efficiency dialysis, *MV* mechanical ventilation.
* $p < 0.05$

vs > 3 dialysis sessions with the same catheter, use of vascular access ≤15 days vs > 15 days, length of ICU stay ≤18 days vs > 18 days, and length of hospital stay ≤28 days vs > 28 days. Patients who underwent more than three dialysis sessions with the same catheter experienced more vascular access line reversals than patients who underwent three or fewer (48% vs 2.8%, $p = 0.005$), but these two groups had no significant difference in the need for catheter replacement (24.0 vs 11.1%, $p = 0.181$). Patients who had the same catheter for more than 15 days experienced fewer mild malfunctions than patients who had the same catheter for 15 days or less (23.5% vs 76.5%, $p = 0.003$), but these two groups had no significant difference in the rate of catheter replacement (5.9% vs 21.2% $p = 0.161$). Patients who stayed more than 18 days in the ICU were more likely to need catheter line reversal than patients who stayed ≤18 days (44.4 vs 11.9%, $p = 0.005$). These two groups also showed a significant difference in the need catheter replacement (33.3 vs 9.5%, $p = 0.023$). Taking into account a length of hospital stay greater than 28 days, all 13 patients with mild malfunction had hospital stays greater than 28 days (32.5% vs 0%, $p = 0.005$). The data for these categorizations and mild malfunction are summarized in Table 4.

Discussion

AKI is associated with higher morbidity and mortality in critically ill cancer patients [9]. Thus, the identification and prevention of complications related to the hemodialysis catheter are fundamental for improving patient care. This study evaluated the clinical predictors of hemodialysis catheter-related complications in critically ill cancer patients.

Most of the patients had solid tumors, for whom surgery was the most common treatment, and 82% had other comorbidities, with SAH being the most common (41.9%). The most commonly used dialysis treatment was the intermittent method, and sepsis was the most frequent AKI etiology. These data corroborate those reported in other studies, which also showed a 78% prevalence of sepsis in cancer patients with AKI admitted to the ICU. Similarly, other studies demonstrated that sepsis was the main cause of AKI, occurring in 51% of the 149 critically ill cancer patients evaluated in a prospective cohort [10, 11].

The presence of metastasis, the use of intermittent dialysis methods, the presence of sepsis, and the use of diuretics after the onset of AKI were more frequent in patients with mild malfunction of hemodialysis catheter. In fact, the neoplasia progression stage and the sites of metastases seem to contribute to hypercoagulability and a higher risk of thrombosis [12, 13]. Sepsis also constitutes a state of hypercoagulability, characterized by several factors: the generation of thrombin over a few hours in response to the presence of endotoxin and tumor

Table 4 Need for catheter line reversal because of mild malfunction of the catheter, and the lengths of ICU and hospital stays

Parameters	Overall		No reversal		With reversal		
	n	%	n	%	n	%	p
Catheter use > 15 days	17	27.4	13	76.5	4	23.5	0.003*
More than 3 HD sessions	25	40.3	13	52.0	12	48.0	< 0.005*
ICU stay > 18 days	18	29.0	10	55.6	8	44.4	0.005*
Hospital stay > 28 days	40	64.5	27	67.5	13	32.5	0.005*

*$p<0.05$

necrosis factor; a reduction in the action of endogenous anticoagulants, such as tissue factor pathway inhibitor, activated C protein and antithrombin; resistance to fibrinolysis; and endothelial damage. Thus, it is postulated that this factor may also contribute to catheter malfunction and the higher rate of line reversal [14]. It should be noted that among the complications studied, only access line reversal is considered a nursing intervention, which is performed autonomously and occurs due to the lack of flow in the vascular access. Thus, this practice favors blood flow in the access, but it reduces the efficiency of dialysis by allowing recirculation of the dialyzed blood [15].

The access implant site had no influence on either line reversals or catheter replacement; however, a trend toward greater malfunction frequency was observed when the catheter was implanted in the right femoral vein. This finding has also been reported in other studies [7, 16] that note that the right femoral access, in addition to being associated with a higher incidence of infection, may be associated with a higher incidence of dysfunction. In part, it is for this reason that the KDIGO AKI guideline [7] recommends the right internal jugular vein as the first-choice access, followed by the femoral vein, left jugular vein and the subclavian veins. It should be noted that in our patients, there was a low rate of infection related to vascular access, which was observed in only one patient. This finding indicates the effectiveness of interventions to reduce the rate of infections in the ICU, which include proper hand hygiene, maximum barrier precaution at the time of catheter insertion (use of a sterile apron, mask, glove, and cap), use of sterile devices, and skin antisepsis with chlorhexidine in the indicated area, among other measures [16].

Another complication that may hamper renal function recovery and prolong the treatment or hospitalization time is the occurrence of severe hemodialysis malfunction. The overall rate of catheter replacement was 16.4%, with 3.3% due to malfunction and 1.6% due to infection. According to a previous study, the conditions associated with this complication include fibrin sheath formation, thrombus within the catheter, and catheter kinks (catheter fracture or disconnection, catheter malposition or migration, and catheter tip adherent to the vessel wall) [17]. In the present study, age greater than 60 years, ECOG status of 3, and use of MV for more than 48 h were predictors of catheter replacement. In fact, these variables characterized a greater severity of the clinical picture, thus contributing to a higher frequency of catheter replacement.

It should be noted that the hemodialysis catheter-related complications were associated with longer stays in the ICU and hospital. In fact, according to an analysis performed in a previous study, the management of vascular access failure is associated with not only the length of hospital stay but also hospital expenses [18]. Thus, it is important to establish measures to prevent catheter dysfunction, such as anticoagulation care in the dialysis system, adequate selection of the catheter material, and use of antisepsis techniques during insertion [19].

This study had some limitations. First, the data were obtained by searching medical records; no clinical-picture severity scores were evaluated. In addition, considering the low frequencies of some catheter-related complications, the study did not have enough statistical power to discriminate all of the predictors evaluated. Additionally, the effect of catheter line reversal on dialysis efficiency via measurement of the effective dialysis dose was not evaluated.

Conclusion

Mild malfunction of the hemodialysis catheter was the complication most frequently associated with hemodialysis access. The access implantation site had no influence on line reversal. The patients with metastasis or sepsis, use of diuretics, or use of intermittent dialysis methods had more frequent mild catheter malfunction. The need for catheter replacement was observed in patients who were older than 60 years, with ECOG status of 3, use of mechanical ventilation for more than 2 days, and more than three metastases. In addition, patients with mild and severe malfunction of the dialysis catheter had longer ICU and hospital stays. The occurrence of only one infectious complication reflected the efficacy of the precautionary measures adopted in the ICU studied, even among immunosuppressed cancer patients.

Abbreviations

AKI: Acute kidney injury; AMI: Acute myocardial infarction; CD: Coronary disease; CHF: Congestive heart failure; CKD: Chronic kidney disease; DM: Diabetes mellitus; ECOG: Eastern Cooperative Oncology Group; HD: Hemodialysis; ICU: Intensive care unit; KDIGO: Kidney Disease: Improving Global Outcomes; MV: Mechanical ventilation.; RDBL: Reversal of dialysis blood lines; RRT: Renal replacement therapy; SAH: Systemic arterial hypertension; SLED: Extended or sustained low-efficiency dialysis

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Availability of data and materials

Please contact author for data requests.

Authors' contributions

EIMM, GAB, JVC, LG, JAA, FPS and BJP participated in the study design and development; collecting, processing, analyzing, and interpreting data; bibliographical research; and manuscript preparation and revision. All authors read and approved the final manuscript.

Authors' information

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Ethics approval and consent to participate
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Consent for publication
Not applicable

Competing interests
The authors declare that they have no competing interests.

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