Kingston Health Sciences Centre
Pharmacy Residency Research Project

A Prospective Analysis of Central Catheter Occlusions to Direct Guideline Development at Kingston Health Sciences Centre

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Submitted in partial fulfillment of the Residency Program in Hospital Pharmacy
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# Table of Contents:

Abstract .................................................................................................................. 4
Background .............................................................................................................. 5
Purpose .................................................................................................................... 7
Objectives .............................................................................................................. 8

## Methods

- Study Population .................................................................................................. 9
- Study Design ......................................................................................................... 10
- Data Collection .................................................................................................... 11
- Statistical Analysis .............................................................................................. 12

## Results ................................................................................................................ 13

## Discussion ........................................................................................................... 16

## Conclusion .......................................................................................................... 21

## References .......................................................................................................... 22

Figure 1: Efficacy of Alteplase to Restore Catheter Patency .................................. 23
Figure 2: Percentage of Central Catheter Occlusions by Service ........................... 24
Figure 3: Percentage of Alteplase 2 mg Vials Used by Service ............................. 25
Figure 4: Rate of Catheter Occlusion by Device Type ........................................... 26

Table 1: Alteplase 2 mg vial Usage by Hospital Floor ............................................ 27
Table 2: Potential Drug Incompatibilities Identified .............................................. 28

Appendix A: Data Collection Sheet ...................................................................... 29
Appendix B: Guideline for the Management of Occluded Central Catheters ....... 30
Abstract:

Background: Catheter occlusions are a common central line complication. Depending on the presumed cause (thrombotic or non-thrombotic), recommended management options vary. Although the incidence of non-thrombotic catheter occlusions is reported in the literature to be as high as 42%, alteplase is the only pharmacologic management option available at Kingston Health Sciences Centre (KHSC). At KHSC, the incidence of alteplase failure and the incidence of non-thrombotic catheter occlusions are unknown.

Objectives: To assess the incidence of potential non-thrombotic causes of central catheter occlusions at KHSC and determine whether there is a role for adding management options in addition to alteplase to the KHSC Drug Formulary. These findings will also be used to develop KHSC Guidelines for the Management of Occluded Central Catheters.

Methods: A prospective chart review of 80 subjects was conducted to assess if alteplase administration restored catheter patency. Daily reports were generated from the Pharmacy Information System to identify patients who were dispensed an alteplase 2 mg vial. The patient’s chart was assessed for documentation in regards to catheter patency restoration post-alteplase administration. The medication administration record was also reviewed for any medications, parenteral nutrition or blood products administered within the previous 24 hours to screen for potential drug incompatibilities or chemical precipitates.

Results: The incidence of alteplase failure to resolve central catheter occlusions was 1.25% (1/80). Of the occlusions that resolved, patency was restored in 97.5% (77/79) following a single alteplase 2 mg dose. Nine potential occlusions secondary to drug incompatibilities were identified, however, all resolved with alteplase administration.

Conclusion: The incidence of non-thrombotic central catheter occlusions is very low at KHSC and alteplase 2 mg is highly effective in restoring catheter patency. These results indicate that alteplase is being used appropriately, and that there is no need to explore alternative pharmacologic strategies for the management of occluded catheters at KHSC.

Key words: alteplase, catheter, occlusion

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Background:

Central catheter devices are frequently used for the administration of intravenous (IV) medications, parenteral nutrition and hydration fluids, and catheter occlusion is a well-documented complication. [1]

The causes of central catheter occlusions are often organized into two categories: thrombotic and non-thrombotic. Thrombotic causes are due to various types of fibrin thrombi at the catheter tip, while non-thrombotic causes include drug/mineral precipitate, lipid residue, or mechanical issues. [1] Results from a single study by Stephens et al. reported that thrombotic causes account for 58% of occluded central catheters, while the other 42% are non-thrombotic in nature. [2] Although this study is widely cited in the literature, of the 42% non-thrombotic causes reported, 83.3% of the catheters had either normal positioning with no evidence of thrombus or any other issues and spontaneously resolved without intervention, or had migrated upon radiographic finding. [2] Furthermore, this study did not report any drug or lipid causes of central catheter occlusion and despite other literature identifying common offending agents, the rate of non-thrombotic catheter occlusion is not clear. [2,3] Identifying the potential cause of the occlusion and treating with an appropriate agent may prevent complications such as delays in receiving therapy and unnecessary device replacement. [4]

Alteplase (Cathflo®) is the only Health Canada approved thrombolytic proven to be safe, effective, and appropriate for restoring patency to occluded central catheters in the adult and pediatric (older than 2 years) population. [5] Combined efficacy data from two phase 3 pivotal trials (COOL-1 and COOL-2)
demonstrated success rates for restoring patency after one and two alteplase 2 mg doses to be 75% and 85.1% respectively. [6] Of note, only patients with a suspected thrombotic cause, after ruling out potential non-thrombotic causes without imaging, were included in these trials. [6] Alteplase is not intended to resolve central catheter occlusions secondary to non-thrombotic causes. For specific drug and lipid non-thrombotic causes of central catheter occlusion, the Canadian Vascular Access Association supports the use of alternative agents such as hydrochloric acid 0.1 N, sodium bicarbonate 8.4%, sodium hydroxide 0.1 N, and ethanol 70%. [4] Currently at KHSC, these alternative agents are not used and alteplase is the only available pharmacologic option for occluded central catheters.

In Fiscal 2016, alteplase 2 mg vials were listed in the Kingston General Hospital site (KGH) Top 25 Drug Expenditures list. A drug use evaluation assessing alteplase 2 mg vial usage at KGH was undertaken as a pharmacy residency project in 2015-2016. Results indicated that of the 50 non-renal patient orders examined, 87% were for occluded central catheters. [7] This study will prospectively determine the incidence of potential non-thrombotic causes of central catheter occlusions (i.e. unsuccessful use of alteplase) at KHSC to determine whether alternative agents should be included in new hospital Guidelines for the Management of Occluded Central Catheters.
**Purpose:**

To determine the incidence of non-thrombotic catheter occlusions at KHSC and assess whether incorporating alternative management strategies into hospital guidelines for occluded central catheters would improve effectiveness and reduce alteplase expenditure.
**Objectives:**

The primary objectives of this research project were:

1. To assess the incidence of potential non-thrombotic causes of central catheter occlusions at KHSC and determine whether there is a role for pharmacologic options in addition to alteplase.
2. To develop KHSC Guidelines for the Management of Occluded Central Catheters.

The secondary objectives of this research project were:

1. To determine the percentage of alteplase 1 mg or 2 mg doses that were unsuccessful in restoring catheter patency.
2. To assess all IV medications administered in the 24-hour period prior to alteplase administration for potential incompatibilities and determine whether there could be a role for an alternative agent to restore catheter patency.
3. To compare the rate of alteplase use for occluded central catheters by Service.
4. To compare the rate of central catheter occlusions by device type.
Methods:

Study Population:

The study was conducted at the KGH site, which is a 469-bed tertiary care teaching hospital located in Kingston, Ontario. Inpatients were included in the study if they were dispensed an alteplase 2 mg vial for any type of occluded central catheter (e.g. peripherally inserted central catheter (PICC), Hickman catheter or implanted port).

Patients in the Renal Dialysis Unit were excluded from the study since there is a separate KHSC protocol already in place for the use of alteplase for the management of occluded hemodialysis catheters. Patients receiving alteplase 2 mg doses in the Cancer Centre of Southeastern Ontario (CCSEO) were also excluded. The reason for this was related to difficulty tracking patient-specific usage due to the lack of automated dispensing cabinets in that area. Overall usage of alteplase at the CCSEO is minimal.

A sample size of 71 subjects was determined using a significance level of 0.05 and a power of 80% based on a hypothesized efficacy rate of 60%. Published trials have reported a 75% efficacy rate after a single dose of alteplase. We chose to use a 60% efficacy rate based on the assumption that we would achieve 80% of this rate (75% X 0.8 = 60%). This is also reflective of the published incidence of 58% of occluded catheters being due to a thrombotic cause. [2,4] Overall, there were 80 subjects included in this study.
Study Design:

This study was designed to prospectively analyze inpatients administered alteplase for the management of occluded central catheters. In order to identify patients, their in-hospital location and the clinical service, daily reports of dispensed alteplase 2 mg vials were generated using the Pharmacy Information System (BDM Pharmacy by BDM IT Solutions®). To determine if alteplase administration was successful in restoring patency, the patients’ chart was reviewed and the physician or bedside nurse assigned to the patient were consulted as needed. To assess for any potential drug incompatibilities, the medication administration record (MAR) was reviewed and assessed using the Micromedex® IV compatibility module. The results were used to develop KHSC Guidelines for the Management of Occluded Central Catheters. A threshold of 10% non-thrombotic catheter occlusions was used to determine if alternative pharmacologic agents should be added to the KHSC Drug Formulary.

As part of the design of this investigation, two assumptions were made. Firstly, it was assumed that the occlusion was of a thrombotic nature if the alteplase administered was successful in restoring patency without removal of central catheter. Patency was verified either via chart documentation, nursing confirmation, or if medications were administered successfully through the central catheter post-alteplase administration. Secondly, it was assumed that the occlusion was the result of a non-thrombotic cause if the patient received up to two consecutive doses of alteplase without catheter patency restoration.
Approval for the study was granted by the Queen’s University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board, in conjunction with the Residency Advisory Committee for the KHSC Pharmacy Residency Program. There are no conflicts of interest expressed by any of the study investigators.

**Data Collection:**

Data collection occurred at the end of each workday Monday through Friday until data for 80 subjects was obtained. Data for alteplase usage over the weekend was collected on the next available weekday. A data collection sheet was created and used to collect patient information in a standardized method. [Appendix A] Information collected included: subject number, in-hospital location, clinical service, type of central catheter, number of lumens occluded, number of alteplase doses received, occlusion resolved (yes/no), medications/nutrition/fluids administered through the central catheter within 24 hours prior to receiving alteplase, drug interaction/incompatibility identification, possible treatment using an alternative agent and general comments.

Once patients were identified, the Pharmacy Resident reviewed the patients’ charts in the respective patient care area. The MAR was reviewed to ensure that alteplase 2 mg had been administered. Next, the Interprofessional Progress Notes section of the chart was reviewed to determine if alteplase administration was successful in restoring catheter function. When applicable, the physician or nurse was consulted to verify that catheter function had been restored. If a description of the occlusion was documented in the chart (e.g.
sluggish blood return, unable to flush/aspirate), a note was made in the general comments section of the data collection sheet. Subsequently, the MAR was reviewed and any IV medications, fluids and parenteral nutrition administered within 24 hours prior to alteplase administration was documented in the relevant section of the data collection sheet. The Therapy section of the chart was also reviewed for blood products administered that would not be otherwise documented on the MAR. The medications identified were then assessed for incompatibilities using the Micromedex® IV compatibility module. The data collected was then inputted and stored into an encrypted Microsoft Excel® spreadsheet.

**Statistical analysis:**

Based on the design of this project, no formal statistical analyses were performed since the results were mainly descriptive in nature. Percentages and frequencies were used to describe the data collected.
Results:

To achieve the desired number of 80 subjects, data collection occurred for a total of 104 days between the following dates: December 4th to 21st 2016, January 1st to February 3rd 2017, February 8th to 17th 2017 and February 26th to April 1st 2017. Gaps in data collection dates reflect periods of resident vacation and conference leaves. Of the 80 subjects assessed, 22.5% (18/80) were reclosures that took place at any point within the data collection period.

The rate of alteplase failure to restore catheter patency was 1.25% (1/80 occlusions). For the one subject where alteplase administration did not successfully restore patency, a chemical precipitate was not likely since no medications were administered in the 24 hours prior to the alteplase. The PICC was ultimately deemed unnecessary and was removed before the administration of a second alteplase dose. Chart documentation by interventional radiology confirmed that the PICC was appropriately positioned prior to the removal of the catheter. When alteplase administration was successful, only a single dose per affected lumen was required 97.5% of the time (77/79 occlusions).

Of note, it was observed that for the 80 subjects included in this study, the type of central catheter device was a PICC in all subjects. More specifically, 96% (77/80) of devices were double lumen PICCs and the remaining 4% (3/80) were single lumen. [Figure 4] Of the 76 double lumen PICCs in which patency was restored, 80% (61/76 devices) only had one occluded lumen. [Figure 1]

When comparing the rate of central catheter occlusions by Service, it was observed that the majority of subjects were under the Oncology Service
(56%), followed by Surgery (16%) and Internal Medicine (14%) services. [Figure 2 for complete distribution] In addition, it was observed that a total of 95 alteplase 2 mg vials were used to resolve the 80 occlusions. The percentage of alteplase 2 mg vials used by Service to resolve the 80 occlusions also closely resembled the distribution of subjects. [Figure 3] This was assessed to discern whether there were any clinical services that had a disproportionate amount of alteplase 2 mg usage relative to the distribution of subjects by Service. In addition, the usage of alteplase 2 mg vials organized by hospital floor was also prepared. [Table 1]

Results of assessing all IV medications, parenteral nutrition and fluids administered in the 24-hour period prior to alteplase administration for potential incompatibilities are summarized in Table 2. Although nine drug combinations were identified as potentially incompatible, in all cases catheter patency was restored with alteplase suggesting that a chemical precipitate was not likely. Of note, 44% (35/80) of subjects had either received no IV medications, a single IV medication or only IV fluids through their PICC in the 24 hours prior to alteplase administration. 12.5% (10/80) of subjects were receiving PN through their PICC however the occlusion occurred in the non-PN lumen in all cases. Furthermore, 16% (13/80) of subjects had received blood products through their PICC in the 24 hours prior to alteplase administration.

Overall, the results indicate that alteplase was highly effective at restoring patency to occluded PICCs and that non-thrombotic causes of catheter occlusions are very rare. As a result, it was determined that there was not a
need to include alternative agents in the KHSC occluded catheter guideline.

[Appendix 2]
**Discussion:**

The results of this trial indicate that alteplase is used appropriately to restore patency in occluded central venous catheters at KHSC. This was demonstrated by a very low overall failure rate, as well as a very high efficacy rate after the administration of a single 2 mg dose. A success rate of 97.5% was observed after a single alteplase dose, which is greater than the rate of 75% reported using the combined data of two pivotal trials in adult patients. [6] It is also important to note that in those trials, only one lumen was treated even if multiple lumens were occluded. In contrast, during our study, 19% (15/80) of subjects had catheters with two occluded lumens and alteplase was instilled into both lumens. A subject was considered as a single occlusive event regardless if they had one or two occluded lumens in our study. If the design considered each occluded lumen separately, our observed efficacy rate would have been even greater. Of note however, a number of patients did experience a re-occlusion during the 4-month data collection period.

All of the occluded central catheters identified during the study period were PICC lines. The Oncology Service had the highest incidence of occluded catheters. [Figure 2] This patient population often requires PICCs for a wide variety of reasons such as administration of chemotherapy, transfusion therapy, and obtaining blood samples as well as to facilitate supportive care including hydration, and electrolytes. There are some potential reasons for why inpatients under the Oncology Service may be at higher risk for occluded central catheter devices compared to other hospitalized patients. Two possible reasons may be
the regular blood work obtained from patients and the administration of blood products to correct haematological deficiencies. This may lead to potential thrombotic occlusions if the catheter lumens are not diligently flushed after aspirating blood or administering blood products, which can linger in the lumen. There is evidence in the literature that indicates the type of central catheter can play a role in occlusion rates in patients undergoing chemotherapy, however guidelines do no support the use of any of specific type of device in all patients with cancer. [8] One study found that in patients with acute myeloid leukemia underdoind induction chemotherapy, rate of central venous catheter device occlusion in PICCs compared Hickman® catheters was 48.2% and 3.2% respectively. [9] Another study conducted at The Ottawa Hospital in a similar patient population reported an occlusion rate of 69.6% and 8.1%, for PICC and Hickman® catheters respectively. [10]

Based on the results of this study, a KHSC Guideline for the Management of Occluded Central Catheters was developed. [Appendix B] Since the threshold to consider the addition of alternative pharmacologic strategies for non-thrombotic occlusions was not met, it was determined that alteplase would remain as the sole agent. A section highlighting the importance of assessing alternative causes of catheter occlusion prior to alteplase administration was included in the guideline.

Although not an objective of the study, the very high efficacy rate suggests the potential for cost minimization through the use of lower alteplase doses. In the literature, a study from the early 2000’s demonstrated that doses as low as
0.5 mg have been shown to have similar efficacy to 1 mg and 2 mg doses. [11]
In addition, a study by Fink et al. compared 1 mg/mL and 2 mg/2 mL doses in
45 patients with occluded implanted ports and tunneled catheters with reported
clearance rates of 81.1% and 83.3% respectively. [12] More recently, a large
single center study by Phohal et al. demonstrated that decreased doses were
highly effective in restoring patency to non-hemodialysis central catheter devices
and can result in significant drug costs savings. [13] In this study, a reduced
dose alteplase protocol was implemented which used 0.5 mg as the first dose,
followed by a 1 mg dose if patency was not restored and finally a 2 mg dose if
patency was not restored after the first two doses. [13] Over a 9-month period, a
total of 1147 doses were assessed and it was found that alteplase 0.5 mg doses
were 93.4% effective in restoring patency after a single dose. Implementation of
this protocol led to a direct drug cost savings in excessive of $80,000. [13]

Furthermore, since most PICC devices have an intraluminal volume of
less than 0.8 mL, the standard 2 mg/2 mL dose exceeds this volume which may
result in drug wastage. [14] A study by Sapienza et al. compared efficacy
between intraluminal 1 mg/mL and standard 2 mg/2 mL alteplase doses
exclusively in adult patients with PICC occlusions. [14] This study found that
1 mg/mL doses were at least as efficacious as the standard dosing with
clearance rates of 85.6% vs. 87.2% after a single dose respectively. Additionally,
there was no significant difference in the number of re-occlusions or time to re-
occlusion compared to standard therapy and offered significant potential cost
savings. [14] At KHSC, PowerPICC® (Bard Access System, Salt Lake City, UT)
is the double lumen PICC device supplied, and has a 5-French catheter with a priming volume of 0.56 mL.

Despite the evidence for lower alteplase doses, the KHSC guidelines recommend the use of a 2 mg dose in catheters with one occluded lumen. This is due to the availability of alteplase (Cathflo®) in a 2 mg single-use vial. The use of a 0.5 mg or 1 mg dose will not result in cost-savings due to wastage of the remainder of the vial. However, in PICCs with two occluded lumens, it is recommended that the 2 mg vial be split between the two lumens for the initial dose. In our trial, one of the 15 PICCs with two occluded lumens was treated with a 1 mg dose in each lumen and both occlusions successfully resolved. If a dose of 1 mg per lumen had been successfully used in the other 14 PICCs, it would have resulted in a cost savings of approximately $1000.00.

There are some limitations that should be considered when interpreting the findings of this trial. Firstly, as part of the study design, two assumptions were made in regards to how catheter occlusions would be classified. All occlusions that resolved after alteplase administration were deemed to be due to a thrombotic cause, whereas those occlusions that failed to resolve after two alteplase 2 mg doses were deemed to be non-thrombotic in nature. The latter situation did not occur during the study period. Alternative study designs whereby occluded central catheters were assessed using imaging methods or were removed and analyzed using laboratory techniques to determine definitive causes of occlusion were beyond the scope of a pharmacy residency project.
Another potential limitation in the study design was the process used to identify subjects. Only patients receiving an alteplase dose were tracked, which implies that the medical team had already determined that the occlusion was likely due to a thrombotic cause. There may have been patients with occluded catheters that were deemed to be due to a non-thrombotic cause who had the catheter removed without a trial of alteplase.

Lastly, if an alteplase vial was removed from the refrigerator connected to the automated dispensing cabinet on the Nursing Unit without linking it to a specific patient profile, that patient name would not appear on the daily computer generated alteplase report and the patient would not be included in the study population.
Conclusion:

From this prospective analysis, it is apparent that the incidence of non-thrombotic central catheter occlusions is significantly lower at KHSC than reported in the literature and that alteplase 2 mg doses are highly effective in restoring catheter patency. Even in cases where potential drug incompatibilities were identified, an alteplase 2 mg dose was successful in restoring catheter patency. These results support the decision not to add alternative pharmacologic options for occluded catheters to the KHSC Drug Formulary at this time. The new KHSC Guidelines for the Use of Alteplase to Manage Occluded Central Venous Catheters will help facilitate the most appropriate use of this medication. There is potential for cost savings related to the use of a 1 mg alteplase dose per lumen in catheters with two occluded lumens, and this is a potential area of future study.
References:

Figure 1: Efficacy of Alteplase to Restore Catheter Patency
Figure 2: Percentage of Central Catheter Occlusions by Service
Figure 3: Percentage of Alteplase 2 mg Vials Used by Service

- Oncology: 60%
- Internal Medicine: 14%
- Neurology + Neurosurgery: 2%
- Critical Care: 6%
- Cardiology: 3%
- Surgery: 15%
Figure 4: Rate of Catheter Occlusion by Device Type

- Single Lumen PICC: 4%
- Double Lumen PICC: 96%
Table 1: Distribution of Alteplase 2 mg vials used by Hospital Floor

<table>
<thead>
<tr>
<th>Hospital Floor</th>
<th>Number of Vials Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connell 9</td>
<td>6</td>
</tr>
<tr>
<td>Connell 10</td>
<td>4</td>
</tr>
<tr>
<td>Davies 3</td>
<td>2</td>
</tr>
<tr>
<td>Davies 4</td>
<td>4</td>
</tr>
<tr>
<td>Davies 5</td>
<td>1</td>
</tr>
<tr>
<td>Kidd 2</td>
<td>6</td>
</tr>
<tr>
<td>Kidd 3</td>
<td>4</td>
</tr>
<tr>
<td>Kidd 6</td>
<td>8</td>
</tr>
<tr>
<td>Kidd 7</td>
<td>1</td>
</tr>
<tr>
<td>Kidd 9</td>
<td>59</td>
</tr>
</tbody>
</table>
Table 2: Potential Drug Incompatibilities Identified

<table>
<thead>
<tr>
<th>Drug Combination</th>
<th>Micromedex IV Incompatibility Module Results (Y-site)</th>
<th>Incidences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnesium sulfate + Haloperidol</td>
<td>Physically Incompatible</td>
<td>1</td>
</tr>
<tr>
<td>Ondansetron + Furosemide</td>
<td>Physically Incompatible</td>
<td>1</td>
</tr>
<tr>
<td>Pantoprazole + Metronidazole</td>
<td>Physically Incompatible</td>
<td>2</td>
</tr>
<tr>
<td>Pantoprazole + Micafungin</td>
<td>Physically Incompatible</td>
<td>1</td>
</tr>
<tr>
<td>Pantoprazole + Ondansetron</td>
<td>Physically Incompatible</td>
<td>1</td>
</tr>
<tr>
<td>Phenytoin + Lorazepam</td>
<td>Physically Incompatible</td>
<td>1*</td>
</tr>
<tr>
<td>Phenytoin + Magnesium sulfate</td>
<td>Physically Incompatible</td>
<td>1*</td>
</tr>
<tr>
<td>Phenytoin + Phenobarbital</td>
<td>Physically Incompatible</td>
<td>1*</td>
</tr>
<tr>
<td>Potassium chloride + Dimenhydrinate</td>
<td>Physically Incompatible</td>
<td>1</td>
</tr>
</tbody>
</table>

*Represent the same patient
Appendix A: Data Collection Sheet

Alteplase Residency Project Data Collection Sheet:

Subject #: _______________________________________________

Service Admitted Under: _________________________________

Type of Central Catheter Device: _________________________

Number of Occluded Lumens: ___________________________

Number of Alteplase Doses Received: _________________

Did the occlusion resolve?:

<table>
<thead>
<tr>
<th>Lumen #1:</th>
<th>Lumen #2:</th>
<th>Lumen #3:</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES / NO</td>
<td>YES / NO</td>
<td>YES / NO</td>
</tr>
</tbody>
</table>

Medications administered through central catheter within 24 hours prior to receiving alteplase:

1. 
2. 
3. 
4. 
5. 
6. 

Drug interaction/incompatibility identified:

1. 
2. 
3. 
4. 
5. 
6. 

Possible treatment using an alternative agent:

Details:

General comments:
Appendix B: Guideline for the Management of Occluded Central Catheters

Kingston Health Sciences Centre

Guidelines for the Use of Alteplase (Cathflo®) to Manage Occluded Central Venous Catheters

Alteplase is indicated for the restoration of patency in a central venous catheter with a thrombotic occlusion. Other potential causes of catheter occlusion should be ruled out prior to administering alteplase:

- Assess for mechanical causes (e.g. kinked line, catheter malposition, closed clamps or clogged filter)
- Assess for potential drug/mineral incompatibilities or precipitates (check Micromedex IV Compatibility Module or contact a pharmacist)
- Assess for lipid deposit (e.g. patients on parenteral nutrition)

Reconstitution:
- Immediately prior to administration, reconstitute alteplase 2 mg vial with 2.2 mL sterile water for injection (SWFI) for final concentration of 1 mg/mL. Gently swirl to mix. Do not shake. Administer once foaming has dissipated.

Administration:
- Administration by Physician only. Exception: RNs who have completed an authorization program may administer alteplase for catheter occlusion. Refer to Nursing Policy Number: C-1850A and B.
- Before instilling alteplase, attempt to remove the occlusion by aspiration. Flush the line with NS. If unable to flush, withdraw the solution from the lumen and proceed with alteplase administration.
- Using a 10 mL syringe, instill alteplase into the occluded lumen. In a double lumen catheter, only instill alteplase into the occluded lumen(s).
- After 30 minutes of dwell time, assess catheter function by attempting to aspirate blood.
  - If the catheter is functional, withdraw 4 to 5 mL of blood (in patients 10 kg or more) or 3 mL of blood (in patients less than 10 kg) to aspirate the alteplase and remaining clot out of the catheter. Irrigate the catheter gently with NS.
  - If catheter function is not restored after 30 minutes, relock the catheter and reassess in another 90 minutes.
- If after 120 minutes of dwell time patency has not been restored, a second dose of alteplase may be administered. Avoid the use of excessive force during alteplase instillation and during attempts to aspirate.

Dosing:
Adults (patients weighing 30 kg and over):
- Usual alteplase dose is 2 mg (2 mL) into each occluded lumen. Lower doses (1 mg) have also been shown to be effective.
- For double lumen catheters, if both lumens are occluded, the instillation of a 1 mg dose into each lumen is recommended.
- If patency is not restored after the maximum dwell time, a subsequent dose of 1 or 2 mg per occluded lumen may be administered. The maximum recommended total dose is 4 mg per 24 hours.


<table>
<thead>
<tr>
<th>Type of catheter</th>
<th>Size of patient</th>
<th>Alteplase dose (1 mg/mL concentration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Lumen (CVL, PICC)</td>
<td>Less than 5 kg</td>
<td>Use amount required to fill volume of line, to maximum of 1 mL = 1 mg</td>
</tr>
<tr>
<td></td>
<td>5 kg or greater</td>
<td>Use amount required to fill volume of line, to maximum of 2 mL = 2 mg</td>
</tr>
<tr>
<td>Double Lumen (CVL, PICC, percutaneous CVL)</td>
<td>Less than 5 kg</td>
<td>Use amount required to fill volume of line, to maximum of 1 mL = 1 mg. Second lumen may not need to be treated if catheter cleared.</td>
</tr>
<tr>
<td></td>
<td>5 kg or greater</td>
<td>Use amount required to fill volume of line, to maximum of 2 mL = 2 mg. Second lumen may not need to be treated if catheter cleared.</td>
</tr>
<tr>
<td>Subcutaneous Ports</td>
<td>Less than 5 kg</td>
<td>Use amount required to fill volume of line, to maximum 1 mL = 1 mg per lumen. If double lumen port, treat one lumen at a time. Second lumen may not need to be treated if port cleared.</td>
</tr>
<tr>
<td></td>
<td>5 kg or greater</td>
<td>Use amount required to fill volume of line, to maximum 2 mL = 2 mg per lumen. If double lumen port, treat one lumen at a time. Second lumen may not need to be treated if port cleared.</td>
</tr>
</tbody>
</table>

Note: after a minimum of 2 hours instillation, withdraw drug; if possible flush the catheter with 0.9% NaCl, attempt to aspirate blood.