American College of Radiology
ACR Appropriateness Criteria®

Central Venous Access Device and Site Selection

Variant: 1 Device selection: Acutely ill patient requiring infusion of an irritant medication, hemodynamic monitoring, and frequent blood draws for 2 weeks or shorter.

Procedure	Appropriateness Category
Nontunneled central venous catheter	Usually Appropriate
PICC	Usually Appropriate
Midline catheter	May Be Appropriate
Tunneled central venous catheter	May Be Appropriate
Arm port	Usually Not Appropriate
Chest port	Usually Not Appropriate

Variant: 2 Device selection: Patient with acute renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for 2 weeks or shorter.

Procedure	Appropriateness Category
Nontunneled dialysis catheter	Usually Appropriate
Tunneled dialysis catheter	Usually Appropriate
Arm port	Usually Not Appropriate
Chest port	Usually Not Appropriate
PICC	Usually Not Appropriate

Variant: 3 Device selection: Patient with renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for more than 2 weeks.

Procedure	Appropriateness Category
Tunneled dialysis catheter	Usually Appropriate
Nontunneled dialysis catheter	May Be Appropriate
Arm port	Usually Not Appropriate
Chest port	Usually Not Appropriate
PICC	Usually Not Appropriate

Variant: 4 Device selection: Patient with cancer diagnosis requiring central venous access for weekly chemotherapy infusion for more than 2 weeks.

Procedure	Appropriateness Category
Chest port	Usually Appropriate
Arm port	Usually Appropriate
PICC	May Be Appropriate
Tunneled central venous catheter	May Be Appropriate
Nontunneled central venous catheter	Usually Not Appropriate

Variant: 5 Device selection: Patient requiring continuous or very frequent intravenous administration of intravenous medications (excluding total parenteral nutrition) for more than 2 weeks.

Procedure	Appropriateness Category
PICC	Usually Appropriate
Tunneled central venous catheter	Usually Appropriate
Chest port	May Be Appropriate
Arm port	May Be Appropriate
Nontunneled central venous catheter	Usually Not Appropriate

Variant: 6 Device selection: Patient requiring long-term total parenteral nutrition and another indication for central access.

Procedure	Appropriateness Category
Tunneled central venous catheter double lumen	Usually Appropriate
Double lumen PICC	Usually Appropriate
Single lumen PICC	May Be Appropriate
Tunneled central venous catheter single lumen	May Be Appropriate
Chest port	May Be Appropriate
Arm port	Usually Not Appropriate

Variant: 7 Device selection: Patient with chronic kidney disease requiring central venous catheter IV infusions for more than 2 weeks.

Procedure	Appropriateness Category
Tunneled central venous catheter single lumen	Usually Appropriate
Tunneled central venous catheter double lumen	Usually Appropriate
Chest port via internal jugular vein	May Be Appropriate
Chest port via subclavian vein	Usually Not Appropriate
Arm port	Usually Not Appropriate
PICC	Usually Not Appropriate

Variant: 8 Site selection: Patient with acute illness requiring central venous catheter for anticipated therapy for 2 weeks or shorter.

Procedure	Appropriateness Category
Right or left internal jugular vein	Usually Appropriate
Right or left subclavian vein	Usually Appropriate
Upper extremity vein	Usually Appropriate
Right or left external jugular vein	May Be Appropriate
Right or left femoral vein	May Be Appropriate
Hepatic vein	Usually Not Appropriate
Inferior vena cava	Usually Not Appropriate

Variant: 9 Site selection: Patient with chronic kidney disease or end-stage renal disease requiring central venous catheter.

Procedure	Appropriateness Category
Right or left internal jugular vein	Usually Appropriate
Right or left external jugular vein	May Be Appropriate
Right or left femoral vein	May Be Appropriate
Inferior vena cava	May Be Appropriate

Right or left subclavian vein	May Be Appropriate
Hepatic vein	Usually Not Appropriate
Upper extremity vein	Usually Not Appropriate

Panel Members

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Summary of Literature Review

Introduction/Background

The use of central venous access devices is ubiquitous in both inpatient and outpatient settings, whether for critical care, oncology, hemodialysis, parenteral nutrition (PN), or diagnostic purposes [1]. Radiology has a well-established role in the placement of central venous access devices because of demonstrated benefits in success rates, fewer complications, shorter procedure time, and cost benefits in multiple clinical settings [2-7]. A wide variety of devices are available for central venous access; however, the indications for these devices often overlap, making optimal device selection a common clinical challenge. This document aims to evaluate the literature supporting the selection of central venous access devices as well as the site of placement of these devices in various clinical settings.

Discussion of Procedures by Variant

Variant 1: Device selection: Acutely ill patient requiring infusion of an irritant medication, hemodynamic monitoring, and frequent blood draws for 2 weeks or shorter.

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A. Arm port

There is no literature to support the use of implantable central venous upper arm ports for acute illness requiring short-term therapy or monitoring. Observational data suggest that nonchemotherapy indication for port placement may be associated with increased risk of infectious complications [8].

Variant 1: Device selection: Acutely ill patient requiring infusion of an irritant medication, hemodynamic monitoring, and frequent blood draws for 2 weeks or shorter.
B. Chest port

There is no literature to support the use of implantable central venous chest ports for acute illness requiring short-term therapy or monitoring. Observational data suggest that nonchemotherapy indication for port placement may be associated with increased risk of infectious complications [8].

Variant 1: Device selection: Acutely ill patient requiring infusion of an irritant medication, hemodynamic monitoring, and frequent blood draws for 2 weeks or shorter.
C. Midline catheter

Because of concerns for phlebitis or tissue injury in cases of extravasation, centrally located catheters have traditionally been preferred for administration of vesicant medications. A single-center prospective randomized clinical trial of 54 patients found no difference in complication rates between patients requiring vancomycin intravenous (IV) infusions via a midline catheter versus peripherally inserted central venous catheter (PICC) [9]. It should be noted that vancomycin is an irritant, not vesicant, medication. Vesicant medications can provoke severe or irreversible tissue injury, and, as such, an extravasation would constitute a stage 4 chemical burn, considered by the Joint Commission to be a sentinel event. Vesicant infusion by midline catheter is not advocated.

A recent prospective cohort study found a low adverse event rate of 0.7 per 1,000 catheter days among midline catheters placed in patients with difficult IV access, prolonged (6-30 days) administration of nonvesicant drugs, or contraindication to central venous catheterization, with the most common adverse event of thrombosis [10].

Variant 1: Device selection: Acutely ill patient requiring infusion of an irritant medication, hemodynamic monitoring, and frequent blood draws for 2 weeks or shorter.
D. Nontunneled central venous catheter

The relative ease of insertion and removal of these catheters in comparison to other types of central access makes nontunneled central venous catheter (CVC) a common choice in the care of the acutely ill patient requiring central access. A systematic review of 63 studies with high heterogeneity evaluated 50,000 CVC devices placed in the critical care setting. Although there were no statistically significant differences in the proportion of device failure before completion of therapy between tunneled and nontunneled CVC, PICC, and hemodialysis catheters, it was found that nontunneled CVC were associated with the highest rate of central line-associated bloodstream infections [11].

The literature is inconclusive when comparing infection rates of nontunneled CVC to PICCs in the inpatient setting. A systematic review including 200 studies from 1966 to 2005 found that standard nontunneled and nonmedicated CVCs placed in the subclavian or internal jugular vein posed a slightly higher risk of catheter-related blood stream infection (2.7 per 1,000 catheter days) compared with PICCs (2.1 per 1,000 catheter days) when used in inpatients. In contrast, a large, prospective study exclusively in the inpatient setting showed that nontunneled CVCs had a slightly lower risk of catheter-related blood stream infection (2.7 per 1,000 catheter days) compared to PICCs (3.5 per 1,000 catheter days) [12-14].

With respect to other catheter-related complications, a study suggested that nontunneled CVC, when compared to PICCs, may have a lower rate of complication resulting in removal prior to completion of therapy; however, it was unclear if this difference reflects variations in the initial catheter indication. A retrospective study of 239 patients admitted to the intensive care unit demonstrated that nontunneled CVCs were associated with a significantly lower incidence of catheter-associated deep vein thrombosis (DVT) in comparison to PICCs (9.6 versus 27.2%, P = .0007), with peak incidence of DVT occurring in the second week after placement [14,15].

Variant 1: Device selection: Acutely ill patient requiring infusion of an irritant medication, hemodynamic monitoring, and frequent blood draws for 2 weeks or shorter.
E. PICC

PICC are nontunneled central catheters inserted through a peripheral vein of the arm that have 1 to 3 lumens and range from 2 to 7 Fr in size. They can be placed by a variety of practitioners and in

different settings, including at bedside, making them another common choice in the care of the acutely ill patient requiring central access.

A systematic review of 63 studies with high heterogeneity evaluated 50,000 CVC devices placed in the critical care setting. There were no statistically significant differences in the proportion of device failure before completion of therapy between tunneled and nontunneled CVC, PICCs, and hemodialysis catheters [11].

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With respect to other catheter-related complications, one study suggested that nontunneled CVC, when compared to PICCs, may have a lower rate of complication resulting in removal before completion of therapy; however, it was unclear if this difference reflects variations in the initial catheter indication. A retrospective study of 239 patients admitted to the intensive care unit demonstrated that nontunneled CVCs were associated with a significantly lower incidence of catheter-associated DVT in comparison to PICCs (9.6 versus 27.2%, $P = .0007$), with peak incidence of DVT occurring in the second week after placement [14,15].

A prospective study evaluating the outcomes of triple lumen PICC placed in the intensive care setting was prematurely terminated because of a high rate of DVT (20% symptomatic, 58% overall) [16].

The available evidence shows no significant difference between CVC and PICC line for central venous pressure monitoring [17].

Variant 1: Device selection: Acutely ill patient requiring infusion of an irritant medication, hemodynamic monitoring, and frequent blood draws for 2 weeks or shorter.
F. Tunneled central venous catheter

Tunneled CVCs are typically placed under fluoroscopic visualization in a sterile procedural suite. Use of tunneled CVCs should be avoided in patients with active bloodstream infections. Because of the more invasive nature of tunneled CVCs, many practitioners prefer to place nontunneled catheters if the anticipated duration of use is short; however, exceptions are made in certain clinical scenarios.

A systematic review including 200 studies found significantly lower rates of catheter-related blood stream infections for cuffed and noncuffed tunneled CVCs in comparison to nontunneled CVCs (1.6 and 1.7 versus 2.7 per 1,000 catheter days). The same study found no significant difference in rates of catheter-related blood stream infections between tunneled CVCs and PICCs. These data made no mention of catheter indication [12].

Variant 2: Device selection: Patient with acute renal failure requiring central venous access

for renal replacement therapy, anticipated duration of therapy for 2 weeks or shorter.

Variant 2: Device selection: Patient with acute renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for 2 weeks or shorter.
A. Arm port

There is no literature to support the use of implantable central venous upper arm ports for renal replacement therapy (RRT). Use of this type of device for RRT is technically limited by the caliber of the access.

Variant 2: Device selection: Patient with acute renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for 2 weeks or shorter.
B. Chest port

There is no literature to support the use of implantable central venous chest ports for RRT. Use of this type of device for RRT is technically limited by the caliber of the access.

Variant 2: Device selection: Patient with acute renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for 2 weeks or shorter.
C. Nontunneled dialysis catheter

In contradistinction to tunneled dialysis catheters, nontunneled dialysis catheters have an advantage of allowing for bedside placement without fluoroscopic visualization. Use of nontunneled dialysis catheters does not need to be avoided in patients with elevated bleeding risk (eg, due to thrombocytopenia or coagulopathy) or active bloodstream infections. However, a recent prospective cohort study in the acute setting found that initial placement of nontunneled dialysis catheters for acute kidney injury was associated with a significantly increased rate of mechanical complications in comparison to tunneled dialysis catheters, with no difference in the rates of positive blood cultures [18].

A meta-analysis including 1,481 nontunneled dialysis catheters placed in the critical care setting found that 7% (95% confidence interval [CI], 3%-12%) of catheters failed before completion of therapy with pooled incidence rate of catheter failure of 11.2 per 1,000 catheter days (95% CI, 0%-22.9%). The pooled incidence rate of catheter-related blood stream infection was 1.69 per 1,000 catheter days (95% CI, 0.70%-2.67%) [11].

Variant 2: Device selection: Patient with acute renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for 2 weeks or shorter.
D. PICC

There is no literature to support the use of PICC for RRT. Use of this type of device for RRT is technically limited by the length and caliber of the catheter.

Variant 2: Device selection: Patient with acute renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for 2 weeks or shorter.
E. Tunneled dialysis catheter

Tunneled dialysis catheters are typically placed under fluoroscopic visualization in a sterile procedural suite. Use of tunneled dialysis catheters should be avoided in patients with elevated bleeding risk (eg, due to thrombocytopenia or coagulopathy) or active bloodstream infections.

A recent prospective cohort study in the acute setting found that initial placement of nontunneled dialysis catheter for acute kidney injury was associated with a significantly increased rate of mechanical complications in comparison to tunneled dialysis catheter, with no difference in the

rates of positive blood cultures [18].

Variant 3: Device selection: Patient with renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for more than 2 weeks.

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A. Arm port

There is no literature to support the use of implantable central venous upper arm ports for RRT. Use of this type of device for RRT is technically limited by the caliber of the access.

Variant 3: Device selection: Patient with renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for more than 2 weeks.
B. Chest port

There is no literature to support the use of implantable central venous chest ports for RRT. Use of this type of device for RRT is technically limited by the caliber of the access.

Variant 3: Device selection: Patient with renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for more than 2 weeks.
C. Nontunneled dialysis catheter

A systematic review of 200 studies found significantly higher rates of catheter-related blood stream infection among nontunneled dialysis catheters in comparison to tunneled dialysis catheters. These data made no mention of the duration of catheter use [12].

There is some data to suggest superiority of precurved over straight nontunneled dialysis catheters. A retrospective multicenter observational cohort study of 1,603 patients showed no significant difference between tunneled dialysis catheters and precurved nontunneled dialysis catheters for the combined endpoint of catheter removal for infection or malfunction. However, tunneled dialysis catheters were less likely to be removed for either infection or malfunction when compared to all (straight and precurved) nontunneled dialysis catheters (hazard ratio [HR] 0.65, P = .02). The duration of catheter use was not controlled for in this study; however, median catheter days in place were 134 and 52 days for tunneled and precurved nontunneled catheters, respectively [19].

Variant 3: Device selection: Patient with renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for more than 2 weeks.
D. PICC

There is no literature to support the use of PICC for RRT. Use of this type of device for RRT is not likely to be technically feasible because of the length and caliber of the catheter.

Variant 3: Device selection: Patient with renal failure requiring central venous access for renal replacement therapy, anticipated duration of therapy for more than 2 weeks.
E. Tunneled dialysis catheter

A systematic review of 200 studies found significantly higher rates of catheter-related blood stream infection among nontunneled dialysis catheters in comparison to tunneled dialysis catheters. These data made no mention of the duration of catheter use [12].

A retrospective multicenter observational cohort study of 1,603 patients showed no significant difference between tunneled dialysis catheters and precurved nontunneled dialysis catheters for

the combined endpoint of catheter removal for infection or malfunction. However, tunneled dialysis catheters were less likely to be removed for either infection or malfunction when compared to all (straight and precurved) nontunneled dialysis catheters (HR 0.65, *P* = .02). The duration of catheter use was not controlled for in this study; however, median catheter days in place were 134 and 52 days for tunneled and precurved nontunneled catheters, respectively [19].

Variant 4: Device selection: Patient with cancer diagnosis requiring central venous access for weekly chemotherapy infusion for more than 2 weeks.

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A. Arm port

Central venous ports have been demonstrated to provide safe, reliable vascular access for cancer patients requiring chemotherapy infusion. Arm ports are less prevalent than chest ports, although the former may be preferred in patients with head and neck tumors, tracheostomies, or anatomic deformities in the chest.

Randomized controlled trial and meta-analysis data have demonstrated lower rates of major complications and all catheter-related adverse events including thrombosis and infection among central venous ports in comparison to PICC. Arm ports comprised the minority of those included in these studies [20-22].

Although retrospective data have suggested upper arm insertion may be an independent risk factor for catheter-related infection, a randomized trial including over 400 patients receiving ports for chemotherapy found no significant difference in early or late complications between cephalic, internal jugular, or subclavian vein port placements. Subclavian placement was noted to have the highest technical success rate in placement [23,24].

A systematic review and meta-analysis of cohort studies concluded that arm ports were associated with the highest rates of venous thromboembolism compared with other nonupper extremity sites [25].

Variant 4: Device selection: Patient with cancer diagnosis requiring central venous access for weekly chemotherapy infusion for more than 2 weeks.
B. Chest port

Central venous ports have been demonstrated to provide safe, reliable vascular access for cancer patients requiring chemotherapy infusion. Chest ports are more prevalent than arm ports, although the latter may be preferred in patients with head and neck tumors, tracheostomies, or anatomic deformities in the chest.

Randomized controlled trial and meta-analysis data have demonstrated lower rates of major complications and all catheter-related adverse events including thrombosis and infection among central venous ports in comparison to PICC. Chest ports comprised the majority of those included in these studies [20-22,25].

Meta-analysis and retrospective data have also found central venous ports to be associated with decreased risk of blood stream infection and other catheter-associated complications in comparison to external CVC in cancer patients [26-28].

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Variant 4: Device selection: Patient with cancer diagnosis requiring central venous access for weekly chemotherapy infusion for more than 2 weeks.
C. Nontunneled central venous catheter

Despite the relative ease of insertion and removal of these catheters in comparison to other types of central venous access, nontunneled CVCs are not ideal for long-term use because of increased risks of infection and dislodgement.

A systematic review including 200 studies from 1966 to 2005 found significantly higher catheter-related blood stream infection rates with nontunneled CVCs in comparison to PICCs placed in the outpatient setting. There were also significantly higher rates of infection in nontunneled CVCs in comparison to tunneled CVCs. These data made no mention of catheter indication [12].

Meta-analysis and retrospective data have also found external CVCs to be associated with increased risk of blood stream infection and other catheter-associated complications in comparison to central venous ports in cancer patients [26-28].

Duration of catheter use is known to correlate to risk of catheter-related blood stream infections. One retrospective study in Japan found a cutoff of 10 days for CVCs (tunneled or nontunneled type not specified) by receiver-operating characteristics, beyond which the odds ratio was 2.867 (95% CI, 1.8-4.5) [28].

Variant 4: Device selection: Patient with cancer diagnosis requiring central venous access for weekly chemotherapy infusion for more than 2 weeks.
D. PICC

Randomized controlled trial and meta-analysis data have demonstrated higher rates of major complications and all catheter-related adverse events including thrombosis and infection among PICCs in comparison to central venous ports [20-22,25].

PICCs have also been shown in retrospective analysis to be associated with higher risk of symptomatic thrombosis than tunneled CVCs in cancer patients [29].

A systematic review including 200 studies from 1966 to 2005 found significantly lower rates of catheter-related blood stream infection in PICCs placed in the outpatient setting in comparison to CVCs. These data made no mention of catheter indication or duration of use [12].

Variant 4: Device selection: Patient with cancer diagnosis requiring central venous access for weekly chemotherapy infusion for more than 2 weeks.
E. Tunneled central venous catheter

One prospective randomized clinical trial compared tunneled CVCs to central venous ports for delivery of IV chemotherapy for a duration of at least 6 months and found ports to be more reliable, safer, and better tolerated by patients [30].

With respect to catheter-related blood stream infection, tunneled CVCs appear to be superior to nontunneled CVCs, equivalent to PICCs, and inferior to ports. A systematic review including 200 studies from 1966 to 2005 found significantly lower rates of catheter-related blood stream infection among cuffed tunneled CVCs in comparison to nontunneled CVCs. When comparing tunneled CVCs to PICCs, this same study found no significant differences in catheter-related blood stream rates. These data made no mention of catheter indication [12].

Meta-analysis and retrospective studies of central venous access devices in cancer patients have also demonstrated external CVCs to be associated with increased risk of blood stream infection and other catheter-associated complications in comparison to venous ports [26-28].

Duration of catheter use is known to correlate to risk of catheter-related blood stream infections. One retrospective study in Japan found a cutoff of 10 days for CVCs (tunneled or nontunneled type not specified) by receiver-operating characteristics, beyond which the odds ratio was 2.867 (95% CI, 1.8-4.5) [28].

With respect to venous thrombosis, tunneled CVCs have been shown in retrospective analysis to be associated with a lower risk of symptomatic thrombosis than PICCs in cancer patients [29].

Variant 5: Device selection: Patient requiring continuous or very frequent intravenous administration of intravenous medications (excluding total parenteral nutrition) for more than 2 weeks.

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A. Arm port

Central venous ports have been demonstrated to provide safe, reliable vascular access for patients requiring IV medications. There are no studies that compare arm ports to other central venous access devices specifically in patients requiring continuous or very frequent IV administration of IV medications. For patients requiring continuous or very frequent infusions, the benefit of a totally implanted device may be diminished if an external needle is present within the device for prolonged periods. Furthermore, there can be discomfort with each needle access occurrence and risks of needle dislodgement and skin breakdown if duration of access is prolonged.

Arm ports are less prevalent than chest ports, although the former may be preferred in patients with head and neck tumors, tracheostomies, or anatomic deformities in the chest.

A systematic review including over 3,000 central venous ports found an infection rate of 0.1 per 1,001 catheter days (95% CI, 0.0-0.1). These data made no mention of the catheter indication or type of port (chest or arm). However, observational data suggest that nonchemotherapy indication for port placement may be associated with increased risk of infectious complications [8,12].

A systematic review and meta-analysis of cohort studies concluded that arm ports were associated with the highest rates of venous thromboembolism compared with other nonupper extremity sites [25].

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administration of intravenous medications (excluding total parenteral nutrition) for more than 2 weeks.

B. Chest port

Central venous ports have been demonstrated to provide safe, reliable vascular access for patients requiring IV medications. There are no studies that compare chest ports to other central venous access devices specifically in patients requiring continuous or very frequent IV administration of IV medications. For patients requiring continuous or very frequent infusions, the benefit of a totally implanted device may be diminished if an external needle is present within the device for prolonged periods. Further, there can be discomfort with each needle access occurrence and risks of needle dislodgement and skin breakdown if duration of access is prolonged.

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Variant 5: Device selection: Patient requiring continuous or very frequent intravenous administration of intravenous medications (excluding total parenteral nutrition) for more than 2 weeks.

C. Nontunneled central venous catheter

Despite the relative ease of insertion and removal of these catheters in comparison to other types of central venous access, nontunneled CVCs are not ideal for long-term use because of increased risks of infection and dislodgement.

Duration of catheter use is known to correlate to risk of catheter-related blood stream infections. One retrospective study in Japan found a cutoff of 10 days for CVCs (tunneled or nontunneled type not specified) by receiver-operating characteristics, beyond which the odds ratio was 2.867 (95% CI, 1.8-4.5) [28].

A systematic review including 200 studies from 1966 to 2005 found significantly higher catheter-related blood stream infection rates with nontunneled CVCs in comparison to PICCs placed in the outpatient setting. There were also significantly higher rates of infection in nontunneled CVCs in comparison to tunneled CVCs. These data made no mention of catheter indication [12].

Variant 5: Device selection: Patient requiring continuous or very frequent intravenous administration of intravenous medications (excluding total parenteral nutrition) for more than 2 weeks.

D. PICC

There are no studies that compare PICCs to other central venous access devices specifically in patients requiring continuous or very frequent IV administration of IV medications. Patients may favor an external CVC over a totally implanted device because of the relative ease with which an

external CVC can be connected to an infusion device. There is also low risk of inadvertent disconnection, which may be beneficial for prolonged infusions.

A systematic review including 200 studies from 1966 to 2005 found significantly lower rates of catheter-related blood stream infections in PICCs placed in the outpatient setting in comparison to nontunneled CVCs (1.0 versus 2.7 per 1,001 catheter days with 95% CI, 0.8-1.2 versus 2.6-2.9, respectively). This study showed no significant difference in rates of catheter-related blood stream infections between PICCs and tunneled CVCs. These data made no mention of catheter indication or duration of use [12].

Data in cancer patients have demonstrated higher rates of major complications and all catheter-related adverse events including thrombosis and infection among PICC in comparison to central venous ports [20-22,25].

Variant 5: Device selection: Patient requiring continuous or very frequent intravenous administration of intravenous medications (excluding total parenteral nutrition) for more than 2 weeks.

E. Tunneled central venous catheter

There are no studies that compare tunneled CVCs to other central venous access devices specifically in patients requiring continuous or very frequent IV administration of IV medications. Patients may favor an external CVC over a totally implanted device because of the relative ease with which an external CVC can be connected to an infusion device. There is also low risk of inadvertent disconnection, which may be beneficial for prolonged infusions.

With respect to catheter-related blood stream infection, tunneled CVCs appear to be superior to nontunneled CVCs, equivalent to PICCs, and inferior to ports. A systematic review including 200 studies from 1966 to 2005 found significantly lower rates of catheter-related blood stream infection among cuffed tunneled CVCs in comparison to nontunneled CVC. When comparing tunneled CVCs to PICCs, this same study found no significant differences in catheter-related blood stream rates. These data made no mention of catheter indication or frequency/duration of use [12].

Meta-analysis and retrospective studies of central venous access device in cancer patients have also demonstrated external CVCs to be associated with increased risk of blood stream infection and other catheter-associated complications in comparison to venous ports [26-28].

Variant 6: Device selection: Patient requiring long-term total parenteral nutrition and another indication for central access.

Variant 6: Device selection: Patient requiring long-term total parenteral nutrition and another indication for central access.

A. Arm port

PN often requires continuous, prolonged infusions 12 to 24 hours in duration. The benefit of a totally implanted device may be diminished if an external needle is present within the device for prolonged periods. Further, there can be discomfort with each needle access occurrence and risks of needle dislodgement and skin breakdown if duration of access is prolonged.

Arm ports are less prevalent than chest ports, although the former may be preferred in patients with head and neck tumors, tracheostomies, or anatomic deformities in the chest.

A recent cohort study of cancer patients requiring home PN prospectively evaluated 854 central venous access devices observed over 169,000 catheter days. The authors found a low overall incidence of catheter-related bloodstream infection (0.29/1,000 catheter days) among all devices, which included ports, PICCs, nontunneled CVCs, and tunneled CVCs. Ports and PICCs had the lowest rates of catheter-related bloodstream infection, reaching statistical difference when compared with nontunneled and tunneled CVCs. For all catheter-related complications, ports and PICCs were again superior when compared with nontunneled and tunneled CVCs. This study did not specify the site of port insertion [31].

In contrast, a retrospective cohort study of over 300 cancer patients receiving home PN failed to demonstrate significant differences in the incidence rates of catheter-related blood stream infection between ports, peripherally inserted CVCs, and tunneled CVCs [32].

Variant 6: Device selection: Patient requiring long-term total parenteral nutrition and another indication for central access.
B. Chest port

PN often requires continuous, prolonged infusions 12 to 24 hours in duration. The benefit of a totally implanted device may be diminished if an external needle is present within the device for prolonged periods. Further, there can be discomfort with each needle access occurrence and risks of needle dislodgement and skin breakdown if duration of access is prolonged.

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Variant 6: Device selection: Patient requiring long-term total parenteral nutrition and another indication for central access.
C. Double lumen PICC

PN often requires continuous, prolonged infusions 12 to 24 hours in duration. Patients may favor an external CVC over a totally implanted device because of the relative ease with which an external CVC can be connected to an infusion device. There is also low risk of inadvertent disconnection, which may be beneficial for prolonged infusions.

A recent cohort study of cancer patients requiring home PN prospectively evaluated 854 central venous access devices observed over 169,000 catheter days. The authors found a low overall

incidence of catheter-related bloodstream infection (0.29/1,000 catheter days) among all devices, which included ports, PICCs, nontunneled CVCs, and tunneled CVCs. Ports and PICCs had the lowest rates of catheter-related bloodstream infection, reaching statistical difference when compared with nontunneled and tunneled CVCs. For all catheter-related complications, ports and PICCs were again superior when compared with nontunneled and tunneled CVCs. This study did not specify the site of port insertion [31].

In contrast, a retrospective cohort study of over 300 cancer patients receiving home PN failed to demonstrate significant differences in the incidence rates of catheter-related blood stream infection between ports, peripherally inserted CVCs, and tunneled CVCs [32].

The European Society for Clinical Nutrition and Metabolism (ESPEN) recommends use of a single lumen device dedicated to PN, or, if another indication for central access exists, dedicating one lumen of a multilumen catheter to PN administration only [33].

Despite this, a recent systematic review, which included only 2 published studies, suggests no definite difference in risk of catheter-related blood stream infection between patients who received PN through a dedicated single lumen catheter and those who received PN through a dedicated lumen of a multilumen catheter [34].

Further, a single observational study suggests that single lumen PICCs may be more prone to cephalad displacement in comparison to double lumen PICCs [35].

Variant 6: Device selection: Patient requiring long-term total parenteral nutrition and another indication for central access.
D. Single lumen PICC

PN often requires continuous, prolonged infusions 12 to 24 hours in duration. Patients may favor an external CVC over a totally implanted device because of the relative ease with which an external CVC can be connected to an infusion device. There is also low risk of inadvertent disconnection, which may be beneficial for prolonged infusions.

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Further, a single observational study suggests that single lumen PICCs may be more prone to cephalad displacement in comparison to double lumen PICCs [35].

Variant 6: Device selection: Patient requiring long-term total parenteral nutrition and another indication for central access.
E. Tunneled central venous catheter double lumen

PN often requires continuous, prolonged infusions 12 to 24 hours in duration. Patients may favor an external CVC over a totally implanted device because of the relative ease with which an external CVC can be connected to an infusion device. There is also low risk of inadvertent disconnection, which may be beneficial for prolonged infusions.

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Variant 6: Device selection: Patient requiring long-term total parenteral nutrition and another indication for central access.
F. Tunneled central venous catheter single lumen

PN often requires continuous, prolonged infusions 12 to 24 hours in duration. Patients may favor an external CVC over a totally implanted device because of the relative ease with which an external CVC can be connected to an infusion device. There is also low risk of inadvertent disconnection, which may be beneficial for prolonged infusions.

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Variant 7: Device selection: Patient with chronic kidney disease requiring central venous catheter IV infusions for more than 2 weeks.

Variant 7: Device selection: Patient with chronic kidney disease requiring central venous catheter IV infusions for more than 2 weeks.
A. Arm port

Preservation of venous access is of particular importance in patients with chronic kidney disease because they may require hemodialysis in the future. As such, long-term catheterization of upper extremity veins should be avoided whenever possible.

A retrospective study found a 7% incidence of central venous stenosis upon venography of patients who had prior upper extremity venous ports and PICC. Those who developed stenosis had significantly longer catheter dwell times than those who did not [36].

Another retrospective investigation of patients with clinically significant central venous stenosis found a significant association with multiple prior CVC insertions. Stenosis was more likely to occur in upper extremity veins [37].

Variant 7: Device selection: Patient with chronic kidney disease requiring central venous catheter IV infusions for more than 2 weeks.
B. Chest port via internal jugular vein

Preservation of venous access is of particular importance in patients with chronic kidney disease because they may require hemodialysis in the future.

There is no literature specifically on the impact of central venous ports on subsequent hemodialysis access; however, retrospective studies have shown that patients who had hemodialysis catheters placed through internal jugular venous access had significantly lower incidence of venous stenosis on venographic follow-up than those whose catheters were placed in

the subclavian vein with 42% to 50% incidence of stenosis associated with subclavian catheters [38,39].

Variant 7: Device selection: Patient with chronic kidney disease requiring central venous catheter IV infusions for more than 2 weeks.
C. Chest port via subclavian vein

Preservation of venous access is of particular importance in patients with chronic kidney disease because they may require hemodialysis in the future.

There is no literature specifically on the impact of central venous ports on subsequent hemodialysis access; however, retrospective studies have shown that patients who had hemodialysis catheters placed through internal jugular venous access had significantly lower incidence of venous stenosis on venographic follow-up than those whose catheters were placed in the subclavian vein with 42% to 50% incidence of stenosis associated with subclavian catheters [38,39].

Variant 7: Device selection: Patient with chronic kidney disease requiring central venous catheter IV infusions for more than 2 weeks.
D. PICC

Preservation of venous access is of particular importance in patients with chronic kidney disease because they may require hemodialysis in the future. As such, long-term catheterization of upper extremity veins should be avoided whenever possible.

Several retrospective and prospective studies have reported high rates of venous thrombosis in association with PICCs in various settings, with incidence ranging from 14% to 58% [15,16,22,25,40-42].

A retrospective study found a 7% incidence of central venous stenosis upon venography of patients who had prior upper extremity venous ports and PICC. Those who developed stenosis had significantly longer catheter dwell times than those who did not [36].

A case-control study of hemodialysis patients without functioning arteriovenous fistulas found PICC use to be independently associated with a lack of functioning arteriovenous fistula [43].

In light of this, the National Kidney Foundation and American Society of Nephrology currently recommend avoidance of PICC placement in hemodialysis patients for preservation of future venous access [44,45].

Variant 7: Device selection: Patient with chronic kidney disease requiring central venous catheter IV infusions for more than 2 weeks.
E. Tunneled central venous catheter double lumen

Preservation of venous access is of particular importance in patients with chronic kidney disease because they may require hemodialysis in the future.

A recent study that followed 108 patients who underwent tunneled small bore (1-3 lumen, 4-6 Fr size) CVC placement over a median of 204 days found no new cases of central or peripheral vein stenosis. There was no direct comparison between catheters of different sizes or lumen number [46].

Variant 7: Device selection: Patient with chronic kidney disease requiring central venous catheter IV infusions for more than 2 weeks.
F. Tunneled central venous catheter single lumen

Preservation of venous access is of particular importance in patients with chronic kidney disease because they may require hemodialysis in the future.

A recent study that followed 108 patients who underwent tunneled small bore (1-3 lumen, 4-6 Fr size) CVC placement over a median of 204 days found no new cases of central or peripheral vein stenosis. There was no direct comparison between catheters of different sizes or lumen number [46].

Variant 8: Site selection: Patient with acute illness requiring central venous catheter for anticipated therapy for 2 weeks or shorter.

Variant 8: Site selection: Patient with acute illness requiring central venous catheter for anticipated therapy for 2 weeks or shorter.
A. Hepatic vein

Because of concerns for higher risk and greater technical challenge of hepatic vein access, the use of a hepatic vein for central venous access is generally limited to patients in whom access via extremity or neck is not possible. Limited data suggest technical feasibility of percutaneous transhepatic catheterization for hemodialysis; however, with high rates of catheter thrombosis (24 per 1,000 catheter days) [47].

There is no literature to support hepatic vein catheterization in the setting of acute illness.

Variant 8: Site selection: Patient with acute illness requiring central venous catheter for anticipated therapy for 2 weeks or shorter.
B. Inferior vena cava

Because of concerns for higher risk and greater technical challenge of inferior vena cava access, the use of the inferior vena cava for central venous access is generally limited to patients in whom access via extremity or neck is not possible.

Retrospective data suggest feasibility of percutaneous translumbar inferior vena cava access for hemodialysis in patients with limited venous access. Reported rates of catheter-related infection were 2.2 to 2.8 per 1,000 catheter days and 6 month patency rates were 52% to 75% [48-50].

There is no literature to support inferior vena cava catheterization in the setting of acute illness.

Variant 8: Site selection: Patient with acute illness requiring central venous catheter for anticipated therapy for 2 weeks or shorter.
C. Right or left external jugular vein

A large retrospective study including over 10,000 catheter insertions found no difference in bleeding complications between subclavian, internal jugular, external jugular, and femoral access sites [52].

A retrospective review of over 1,000 external jugular venous ports placed primarily by cut-down technique found technical success rates of 74% to 100% with complication rates of up to 13% [53].

A small prospective cohort study of 45 percutaneous port placements through external jugular access with prior planning CT venography reported a 93% technical success rate and a 9% over all complication rate [54].

Extrapolation of these data to the acute care setting should be considered with caution.

Variant 8: Site selection: Patient with acute illness requiring central venous catheter for anticipated therapy for 2 weeks or shorter.
D. Right or left femoral vein

Multiple randomized and observational prospective studies in inpatient settings have associated femoral approach central venous catheterization with increased rates of catheter-associated blood stream infection and venous thrombosis [55-60].

A Cochrane systematic review of randomized clinical trials concluded that femoral access sites were associated with higher risks of catheter colonization and thrombotic complications for shorter-term catheterization in critically ill patients [61].

A study in Chinese cancer patients with superior vena cava syndrome found that PICCs inserted through a femoral vein resulted in no significant difference in mechanical or delayed complications in comparison to upper extremity PICC [51].

Variant 8: Site selection: Patient with acute illness requiring central venous catheter for anticipated therapy for 2 weeks or shorter.
E. Right or left internal jugular vein

Randomized and observational prospective studies in the intensive care setting have demonstrated increased rates of catheter-related infection and major complications (infection and symptomatic venous thrombosis) among internal jugular CVCs in comparison to subclavian approach [56,58].

Although retrospective studies have failed to demonstrate differences in bleeding, mechanical complications, and delated complications related to catheter site, other data including a randomized controlled trial have shown decreased rates of pneumothorax with internal jugular in comparison to subclavian approach catheters [52,58,62].

Variant 8: Site selection: Patient with acute illness requiring central venous catheter for anticipated therapy for 2 weeks or shorter.
F. Right or left subclavian vein

Multiple randomized and observational prospective studies as well as meta-analysis data have demonstrated decreased rate of catheter-associated blood stream infection and major complications (infection and symptomatic venous thrombosis) with subclavian in comparison to femoral and internal jugular CVCs in the short-term setting [56-58,61].

While retrospective studies have failed to demonstrate differences in bleeding, mechanical complications, and delayed complications related to catheter site, other data including a randomized controlled trial have shown increased rates of pneumothorax with subclavian in comparison to internal jugular approach catheters [52,58,62].

Variant 8: Site selection: Patient with acute illness requiring central venous catheter for anticipated therapy for 2 weeks or shorter.
G. Upper extremity vein

PICC are inserted through a peripheral vein, generally through a cephalic, basilic, or brachial vein in the arm. They can be placed by a variety of practitioners and in different settings, including at bedside, making them a common choice in the care of the acutely ill patient requiring central access.

A systematic review of 63 studies with high heterogeneity evaluated 50,000 CVC devices placed in the critical care setting. There were no statistically significant differences in the proportion of device failure before completion of therapy between tunneled and nontunneled CVC, PICC, and hemodialysis catheters [11].

The literature is inconclusive when comparing infection rates of nontunneled CVC to PICCs in the inpatient setting. A systematic review including 200 studies from 1966 to 2005 found that standard nontunneled and nonmedicated CVCs placed in the subclavian or internal jugular vein posed a slightly higher risk of catheter-related blood stream infection (2.7 per 1,000 catheter days) compared with PICCs (2.1 per 1,000 catheter days) when used in inpatients. In contrast, a large, prospective study exclusively in the inpatient setting showed that nontunneled CVCs had a slightly lower risk of catheter-related blood stream infection (2.7 per 1,000 catheter days) compared to PICCs (3.5 per 1,000 catheter days) [12-14].

In the postcritical care setting, PICC may be associated with a higher incidence of catheter-associated DVT in comparison to CVCs (27.2 versus 9.6%, $P = .0007$), with peak incidence occurring in the second week after placement [15].

A study in Chinese cancer patients with superior vena cava syndrome found that PICCs inserted through a femoral vein resulted in no significant difference in mechanical or delayed complications in comparison to upper extremity PICC [51].

Variant 9: Site selection: Patient with chronic kidney disease or end-stage renal disease requiring central venous catheter.

Variant 9: Site selection: Patient with chronic kidney disease or end-stage renal disease requiring central venous catheter.
A. Hepatic vein

Because of concerns for higher risk and greater technical challenge of hepatic vein access, the use of a hepatic vein for central venous access is generally limited to patients in whom access via extremity or neck is not possible. Limited data suggest technical feasibility of percutaneous transhepatic catheterization for hemodialysis; however, with high rates of catheter thrombosis (24 per 1,000 catheter days) [47].

Variant 9: Site selection: Patient with chronic kidney disease or end-stage renal disease requiring central venous catheter.
B. Inferior vena cava

Because of concerns for higher risk and greater technical challenge of inferior vena cava access, the use of the inferior vena cava for central venous access is generally limited to patients in whom access via extremity or neck is not possible.

Despite this, a retrospective study of CT-guided translumbar placement of hemodialysis catheters access found no significant difference in technical success, primary assisted patency, and minor or

major complications in comparison to jugular approach catheters [63].

Other retrospective data suggest feasibility of percutaneous translumbar inferior vena cava access in hemodialysis patients with limited venous access. Reported rates of catheter-related infection were 2.2 to 2.8 per 1,000 catheter days, and 6 month patency rates were 52% to 75% [48-50].

Variant 9: Site selection: Patient with chronic kidney disease or end-stage renal disease requiring central venous catheter.
C. Right or left external jugular vein

Preservation of venous access is of particular importance in patients with chronic kidney disease because they may require hemodialysis in the future. Although limited data suggest feasibility of external jugular venous access, there is no literature evaluating external jugular venous access as it applies to the patient with chronic kidney disease [53].

Variant 9: Site selection: Patient with chronic kidney disease or end-stage renal disease requiring central venous catheter.
D. Right or left femoral vein

Preservation of venous access is of particular importance in patients with chronic kidney disease because they may require hemodialysis in the future.

Multiple randomized prospective studies have found increased rates of catheter-associated thrombosis with femoral catheters in comparison to upper body sites, but these data were not specific for the chronic kidney disease population [57,58,60].

A prospective study of hemodialysis catheters found that tunneled femoral were noninferior to upper body (subclavian or internal jugular) catheters in terms of blood flow rate or rate of catheter-associated infection for 36 months of follow-up [64].

A Cochrane systematic review of randomized clinical trials concluded that, in CVCs for short term hemodialysis, femoral compared with internal jugular access had similar risks of catheter-related complications overall. However, femoral compared with internal jugular access was associated with fewer mechanical complications [61].

Variant 9: Site selection: Patient with chronic kidney disease or end-stage renal disease requiring central venous catheter.
E. Right or left internal jugular vein

Preservation of venous access is of particular importance in patients with chronic kidney disease because they may require hemodialysis in the future.

Retrospective studies have shown that patients who had hemodialysis catheters placed through internal jugular venous access had significantly lower incidence of venous stenosis on venographic follow-up than those whose catheters were placed in the subclavian vein, with 42% to 50% incidence of stenosis associated with subclavian catheters [38,39].

A Cochrane systematic review of randomized clinical trials concluded that, in CVCs for short term hemodialysis, femoral compared with internal jugular access had similar risks of catheter-related complications overall. However, femoral compared with internal jugular access was associated with fewer mechanical complications [61].

Variant 9: Site selection: Patient with chronic kidney disease or end-stage renal disease requiring central venous catheter.
F. Right or left subclavian vein

Preservation of venous access is of particular importance in patients with chronic kidney disease because they may require hemodialysis in the future.

Retrospective studies have shown that patients who had hemodialysis catheters placed through internal jugular venous access had significantly lower incidence of venous stenosis on venographic follow-up than those whose catheters were placed in the subclavian vein, with 42% to 50% incidence of stenosis associated with subclavian catheters [38,39].

Variant 9: Site selection: Patient with chronic kidney disease or end-stage renal disease requiring central venous catheter.
G. Upper extremity vein

Preservation of venous access is of particular importance in patients with chronic kidney disease because they may require hemodialysis in the future. As such, long-term catheterization of upper extremity veins should be avoided whenever possible.

Several retrospective and prospective studies have reported high rates of venous thrombosis in association with PICCs in various settings, with incidence ranging from 14% to 58% [15,16,22,40-42].

A retrospective study found a 7% incidence of central venous stenosis upon venography of patients who had prior upper extremity venous ports and PICC. Those who developed stenosis had significantly longer catheter dwell times than those who did not [36].

A case-control study of hemodialysis patients without functioning arteriovenous fistulas found PICC use to be independently associated with lack of functioning arteriovenous fistula [43].

In light of this the National Kidney Foundation and American Society of Nephrology currently recommend avoidance of PICC placement in hemodialysis patients for preservation of future venous access [44,45].

Summary of Highlights

- **Variant 1**: A nontunneled CVC or PICC is usually appropriate for device selection in an acutely ill patient requiring infusion of vesicant medication, hemodynamic monitoring, and frequent blood draws for 2 weeks or shorter. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 2**: A nontunneled dialysis catheter or tunneled dialysis catheter is usually appropriate for device selection in a patient with acute renal failure requiring central venous access for RRT with an anticipated duration of therapy for 2 weeks or shorter. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 3**: A tunneled dialysis catheter is usually appropriate for device selection in a patient with renal failure requiring central venous access for RRT with an anticipated duration of

therapy for more than 2 weeks.

- **Variant 4**: A chest port or arm port is usually appropriate for device selection in a patient with a cancer diagnosis requiring central venous access for weekly chemotherapy infusion for more than 2 weeks. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 5**: A PICC or tunneled CVC is usually appropriate for device selection in a patient requiring continuous or very frequent IV administration of IV medications (excluding total PN) for more than 2 weeks. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 6**: A double lumen tunneled CVC or double lumen PICC is usually appropriate for device selection in a patient requiring long-term total PN and another indication for central access. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 7**: A single or double lumen tunneled CVC is usually appropriate for device selection in a patient with chronic kidney disease requiring CVC IV infusions for more than 2 weeks. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 8**: The right or left internal jugular vein, right or left subclavian vein, or upper extremity vein is usually appropriate for site selection in a patient with acute illness requiring CVC for anticipated therapy for 2 weeks or shorter. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 9**: The right or left internal jugular vein is usually appropriate for site selection in a patient with chronic kidney disease or end-stage renal disease requiring CVC.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

Gender Equality and Inclusivity Clause

The ACR acknowledges the limitations in applying inclusive language when citing research studies that predates the use of the current understanding of language inclusive of diversity in sex, intersex, gender, and gender-diverse people. The data variables regarding sex and gender used in the cited literature will not be changed. However, this guideline will use the terminology and definitions as proposed by the National Institutes of Health.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition

Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

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treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

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