Radiologic Management of Central Venous Access
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
1. Dariushnia SR, Wallace MJ, Siddiqi NH, et al. Quality improvement guidelines for central venous access. *J Vasc Interv Radiol.* 2010;21(7):976-981.	Review/Other-Tx	N/A	No abstract available.	No abstract available.	4
2. Basford TJ, Poenaru D, Silva M. Comparison of delayed complications of central venous catheters placed surgically or radiologically in pediatric oncology patients. *J Pediatr Surg.* 2003;38(5):788-792.	Observational-Tx	98 CVCs, 52 external tunneled catheters, 46 subcutaneous ports, in 67 patients	To compare the frequency of delayed complications in CVCs placed surgically or radiologically in a pediatric oncology population.	Median patient age was 6.1 years for children with external catheters and 7.8 years for those with ports. Both infectious and mechanical complications were significantly more common among surgically placed external tunneled catheters than those placed radiologically ($P<.05$). Complications per 1,000 catheter days and premature removal showed a trend toward greater frequency among surgical external tunneled catheters, although this did not reach statistical significance. No consistent trends were seen in complications among ports.	2
3. Busch JD, Herrmann J, Heller F, et al. Follow-up of radiologically totally implanted central venous access ports of the upper arm: long-term complications in 127,750 catheter-days. *AJR Am J Roentgenol.* 2012;199(2):447-452.	Review/Other-Tx	512 complete datasets of procedures	To retrospectively evaluate radiologically totally implanted central venous access ports of the upper arm in terms of safety, technical feasibility, and device-related complications.	In 507 patients, a total of 523 devices were implanted. Of these 523 procedures, 512 complete datasets were available during follow-up. The primary technical success rate was 99.04%. All procedures were completed without major complications. During follow-up and with a total number of 127,750 days of totally implanted central venous access port implantation (248 +/- 279 days/patient; range, 1–1687 days/patient), 50 devices had to be revised because of complications (9.8%). Complications occurred at a mean of 114 +/- 183 days (range, 1–1113 days) after placement. Early complications were noted in 21/512 cases (4.1%), and late complications were noted in 29/512 cases (5.7%). Complications were as follows: local infections, 4.9% (25/512); systemic infections, 0.4% (2/512); venous thrombosis, 1.6% (8/512); paralysis of the median nerve, 0.6% (3/512); skin dehiscence at the port site, 0.2% (1/512); and mechanical problems including catheter line displacement, port hub rotation, and catheter fracture, 2.1% (11/512).	4

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4. Koroglu M, Demir M, Koroglu BK, et al. Percutaneous placement of central venous catheters: comparing the anatomical landmark method with the radiologically guided technique for central venous catheterization through the internal jugular vein in emergent hemodialysis patients. *Acta Radiol.* 2006;47(1):43-47.	Experimental-Tx	40 anatomical landmark method; 40 radiologically guided technique	To compare the success and immediate complication rates of the anatomical landmark method (group 1) and the radiologically (combined real-time US and fluoroscopy) guided technique (group 2) in the placement of CVCs in emergent hemodialysis patients.	The groups were comparable in age and sex. The indication for catheter placement was hemodialysis access in all patients. Catheter placement was successful in all patients in group 2 and unsuccessful in 1 (2.5%) patient in group 1. All catheters functioned adequately and immediately after the placement (0% initial failure rate) in group 2, but 3 catheters (7.5% initial failure rate) were nonfunctional just after placement in group 1. The total number of needle passes, double venous wall puncture, and complication rate were significantly lower in group 2.	1
5. Reeves AR, Seshadri R, Trerotola SO. Recent trends in central venous catheter placement: a comparison of interventional radiology with other specialties. *J Vasc Interv Radiol.* 2001;12(10):1211-1214.	Review/Other-Tx	N/A	To determine the percentage of venous access procedures performed by each specialty in the last 5 years and to evaluate trends in venous access. A secondary goal was to track overall growth of venous access procedures in interventional radiology.	The authors determined changing trends and growth in tunneled and nontunneled CVC placement procedures. With use of Medicare billing data for tunneled and nontunneled catheter placement, a comparison was made among interventional radiology, surgery, anesthesia, and internal medicine. There has been substantial growth in the placement of CVCs. Currently, a minority of these procedures are performed in interventional radiology departments. However, there has been significant growth in the radiologic placement of both types of catheters.	4
6. Teichgraber UK, Kausche S, Nagel SN, Gebauer B. Outcome analysis in 3,160 implantations of radiologically guided placements of totally implantable central venous port systems. *Eur Radiol.* 2011;21(6):1224-1232.	Review/Other-Tx	3,160 port catheter systems	To evaluate the success and complication rates after radiologically guided port catheter implantation.	922,599 catheter days (mean, 292 days; range, 0–2,704 days) were documented. The implantation was successful in 3,153 (99.8%) cases. A total of 374 (11.8%; 0.41/1,000 catheter days) adverse events were recorded. Of these, 42 (1.33%) were periprocedural complications. 86 (3.3%; 0.09/1,000 catheter days) early and 246 (9.4%; 0.27/1,000 catheter days) late onset complications occurred after port implantation. The most common complications were blood stream infection (n = 134; 5.1%; 0.15/1,000 catheter days), catheter-induced venous thrombosis (n = 97; 3.7%; 0.11/1,000 catheter days) and catheter migration (n = 34; 1.3%; 0.04/1,000 catheter days). A total of 193 (6.1%) port explantations were required.	4

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7. Leonidou L, Gogos CA. Catheter-related bloodstream infections: catheter management according to pathogen. *Int J Antimicrob Agents.* 2010;36 Suppl 2:S26-32.	Review/Other-Tx	N/A	To outline the epidemiology, pathogenesis, diagnosis, microbiology and management of CRI, mainly focusing on the management of the intravascular device according to the pathogen.	No results stated in abstract.	4
8. Dezfulian C, Lavelle J, Nallamothu BK, Kaufman SR, Saint S. Rates of infection for single-lumen versus multilumen central venous catheters: a meta-analysis. *Crit Care Med.* 2003;31(9):2385-2390.	Meta-analysis	15 studies; 6,199 catheters	To determine the risk of CRBSI and catheter colonization in multilumen catheters compared with single-lumen catheters.	A total of 15 studies met inclusion criteria. Summary ORs were calculated using a random-effects model. Although CRBSI was more common in multilumen catheters (summary ORs, 2.15; 95% CI, 1.00–4.66), catheter colonization was not (summary ORs, 1.78; 95% CI, 0.92–3.47). Tests for heterogeneity, however, suggested substantial variation by study. When only studies of higher quality were included, multilumen catheters were found not to be associated with a significant increase in CRBSI prevalence (summary ORs, 1.30; 95% CI, 0.50–3.41).	M
9. Knutstad K, Hager B, Hauser M. Radiologic diagnosis and management of complications related to central venous access. *Acta Radiol.* 2003;44(5):508-516.	Review/Other-Tx	N/A	To provide an overview of different types of delayed CVC complications and discuss therapeutic options based on interventional radiology techniques.	Radiology plays a central role in the management of patients with CVCs. In most cases radiologic modalities will provide the cause of catheter dysfunction or catheter-related venous thrombosis, as well as the location of intravascular foreign bodies. For all these conditions, various interventional radiologic techniques with a low complication risk can be offered. These techniques will eventually lead to extended catheter survival. With respect to more advanced CVC systems such as tunneled catheters or venous access ports, device removal and reinsertion can often be obviated. In patients with technically challenging venous anatomy or increased risk for complications, image-guided insertion should be the method of choice.	4

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10. Pittiruti M, Hamilton H, Biffi R, MacFie J, Pertkiewicz M. ESPEN Guidelines on Parenteral Nutrition: central venous catheters (access, care, diagnosis and therapy of complications). *Clin Nutr.* 2009;28(4):365-377.	Review/Other-Tx	N/A	To provide general recommendations about the indications for and the use of the different types of venous access devices available for parenteral nutrition.	The most appropriate site for central venous access will take into account many factors, including the patient's conditions and the RR of infective and noninfective complications associated with each site. US-guided venepuncture is strongly recommended for access to all central veins. For parenteral nutrition, the ideal position of the catheter tip is between the lower third of the superior cava vein and the upper third of the right atrium; this should preferably be checked during the procedure. CRBSI is an important and still too common complication of parenteral nutrition. The risk of infection can be reduced by adopting cost-effective, evidence-based interventions such as proper education and specific training of the staff, an adequate hand washing policy, proper choices of the type of device and the site of insertion, use of maximal barrier protection during insertion, use of chlorhexidine as antiseptic prior to insertion and for disinfecting the exit site thereafter, appropriate policies for the dressing of the exit site, routine changes of administration sets, and removal of central lines as soon as they are no longer necessary. Most noninfective complications of CVADS can also be prevented by appropriate, standardized protocols for line insertion and maintenance. These too depend on appropriate choice of device, skilled implantation and correct positioning of the catheter, adequate stabilization of the device (preferably avoiding stitches), and the use of infusion pumps, as well as adequate policies for flushing and locking lines which are not in use.	4

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11. Maki DG, Ringer M. Evaluation of dressing regimens for prevention of infection with peripheral intravenous catheters. Gauze, a transparent polyurethane dressing, and an iodophor-transparent dressing. *JAMA*. 1987;258(17):2396-2403.	Experimental-Tx	2,088 catheters from 1,259 patients	To study in a prospective randomized clinical trial 4 dressing regimens for peripheral venous catheters with 2,088 Teflon catheters.	The 4 dressings provided comparable coverage, except moisture accumulated more frequently under the transparent dressings (26% to 28% vs 20% to 21%). Cutaneous colonization under the dressing was low level and comparable with all 4 dressings (range, 10(0.58) to 10(0.70) colony-forming units). The rate of local CRI (≥15 colony-forming units) was also low and did not differ significantly (range, 4.6% to 5.9%); no catheter caused bacteremia. Stepwise logistic multivariate analysis showed cutaneous colonization of the insertion site (RR of infection, 3.86), contamination of the catheter hub (RR, 3.78), moisture under the dressing (RR, 2.48), and prolonged catheterization (RR, 1.75) to be significant risk factors for CRI.	1
12. Sheth NK, Franson TR, Rose HD, Buckmire FL, Cooper JA, Sohnle PG. Colonization of bacteria on polyvinyl chloride and Teflon intravascular catheters in hospitalized patients. *J Clin Microbiol.* 1983;18(5):1061-1063.	Observational-Tx	687 Teflon and 77 polyvinyl chloride catheters	To analyze differences in rates of bacterial colonization of PVC and Teflon catheters during clinical use and to compare the bacterial species involved.	Of the 687 Teflon catheters cultured, 6.9% were positive by culture, compared with 24.6% of 77 polyvinyl chloride catheters ($P<0.001$). Also, colonization of coagulase-negative staphylococci on polyvinyl chloride was more than on Teflon. These data suggest that polyvinyl chloride catheters are colonized more frequently with organisms than are Teflon catheters; additionally, there is an increased affinity of coagulase-negative staphylococci for polyvinyl chloride as compared with Teflon, substantiating our previous observations with an in vitro system.	2
13. Crnich CJ, Halfmann JA, Crone WC, Maki DG. The effects of prolonged ethanol exposure on the mechanical properties of polyurethane and silicone catheters used for intravascular access. *Infect Control Hosp Epidemiol.* 2005;26(8):708-714.	Observational-Tx	15 polyetheruret hane/16 silicone locked with 70% ethanol; 17 polyetheruret hane/17 silicone control	The study the effects of alcohol on the integrity of intravascular devices.	No significant differences between exposed and unexposed catheters were identified for any of the mechanical parameters tested except for a marginal reduction in the modulus of elasticity for both polyetherurethane and silicone catheters and minor increases in the wall area of polyetherurethane catheters.	2

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14. Mermel LA. Prevention of intravascular catheter-related infections. *Ann Intern Med.* 2000;132(5):391-402.	Review/Other-Tx	N/A	To review the literature on prevention of intravascular CRI.	The recommended preventive strategies with the strongest supportive evidence are full barrier precautions during CVC insertion; subcutaneous tunneling short-term catheters inserted in the internal jugular or femoral veins when catheters are not used for drawing blood; contamination shields for pulmonary artery catheters; povidone-iodine ointment applied to insertion sites of hemodialysis catheters; specialized nursing teams caring for patients with short-term peripheral venous catheters, especially at institutions with a high incidence of CRI; no routine replacement of CVCs; antiseptic chamber filled hub or hub-protective antiseptic sponge for CVCs; and use of chlorhexidine-silver sulfadiazine-impregnated or minocycline-rifampin-impregnated short-term CVCs if the rate of infection is high despite adherence to other strategies that do not incorporate antimicrobial agents (for example, maximal barrier precautions).	4
15. Veenstra DL, Saint S, Saha S, Lumley T, Sullivan SD. Efficacy of antiseptic-impregnated central venous catheters in preventing catheter-related bloodstream infection: a meta-analysis. *JAMA*. 1999;281(3):261-267.	Meta-analysis	12 studies; 2,611 catheters - catheter colonization 11 studies; 2,603 catheters - CRBSI	To evaluate the efficacy of chlorhexidine-silver sulfadiazine-impregnated CVCs in the prevention of CRBSI.	The summary OR for catheter colonization was 0.44 (95% CI, 0.36–0.54; $P<.001$), indicating a significant decrease in catheter colonization associated with impregnated catheters. The studies examining the outcome of primary interest, CRBSI, had a summary OR of 0.56 (95% CI, 0.37–-0.84; $P=.005$).	M

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16. Brun-Buisson C, Doyon F, Sollet JP, Cochard JF, Cohen Y, Nitenberg G. Prevention of intravascular catheter-related infection with newer chlorhexidine-silver sulfadiazine-coated catheters: a randomized controlled trial. *Intensive Care Med.* 2004;30(5):837-843.	Experimental-Tx	363 patients with catheter insertion	To test the ability of the new generation of chlorhexidine-silver and sulfadiazine-coated catheters, with enhanced antiseptic coating, to reduce the risk of CVC-related infection in ICU patients.	Of 367 patients having a successful catheter insertion, 363 were analyzed (175 non-coated catheters and 188 antiseptic-coated catheters). Patients had 1 (non-coated catheters =162, antiseptic-coated catheters =180) or more (non-coated catheters =13, antiseptic-coated catheters =11) CVC inserted. The 2 groups were similar for insertion site [subclavian (64 vs 69)] or jugular (36 vs 31%)], and type of catheters (single-lumen 18% vs 18%; double-lumen 82% vs 82%), and mean (median) duration of catheterization [12.0+/-11.7 (9) vs 10.5+/-8.8 (8) days in the non-coated catheter and antiseptic-coated catheter groups, respectively]. Significant colonization of the catheter occurred in 23 (13.1%) and 7 (3.7%) patients, respectively, in the non-coated catheter and antiseptic-coated catheter groups (11 vs 3.6 per 1000 catheter-days; *P*=0.01); CVC-related infection (bloodstream infection) occurred in 10 (5) and 4 (3) patients in the non-coated catheter and antiseptic-coated catheter groups, respectively (5.2 vs 2 per 1000 catheter days; *P*=0.10).	1
17. Ostendorf T, Meinhold A, Harter C, et al. Chlorhexidine and silver-sulfadiazine coated central venous catheters in haematological patients--a double-blind, randomised, prospective, controlled trial. *Support Care Cancer.* 2005;13(12):993-1000.	Experimental-Tx	184 catheters, of which 90 were antiseptically coated	To investigate a novel version of chlorhexidine and silver sulfadiazine coated catheters in a prospective, double-blind trial to determine the efficacy of antiseptic coating in preventing CRI amongst hematological patients undergoing chemotherapy.	Catheters coated with chlorhexidine and silver sulfadiazine were effective in reducing the rate of significant bacterial growth on either the tip or subcutaneous segment (26%) compared to control catheters (49%). The incidence of catheter colonization was also significantly reduced (12% coated vs 33% uncoated). Data obtained show a significant reduction of catheter colonization in chlorhexidine and silver sulfadiazine catheters. There was no significant difference in the incidence of catheter-related bacteremia (3% coated vs 7% uncoated). However, due to the overall low rate of CRI, we could not observe a significant reduction in the incidence of catheter-related bacteremia.	1

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18. Rupp ME, Lisco SJ, Lipsett PA, et al. Effect of a second-generation venous catheter impregnated with chlorhexidine and silver sulfadiazine on central catheter-related infections: a randomized, controlled trial. *Ann Intern Med.* 2005;143(8):570-580.	Experimental-Tx	780 patients	To ascertain 1) effectiveness of a second-generation antiseptic-coated catheter in the prevention of microbial colonization and infection; 2) safety and tolerability of this device; 3) microbiology of infected catheters; and 4) propensity for the development of antiseptic resistance.	Patients with the 2 types of catheters had similar demographic features, clinical interventions, laboratory values, and risk factors for infection. Antiseptic catheters were less likely to be colonized at the time of removal compared with control catheters (13.3 vs 24.1 colonized catheters per 1000 catheter-days; $P<0.01$). The center-stratified Cox regression HR for colonization controlling for sampling design and potentially confounding variables was 0.45 (95% CI, 0.25 to 0.78). The rate of definitive CRBSI was 1.24 per 1000 catheter-days (CI, 0.26 to 3.62 per 1000 catheter-days) for the control group vs 0.42 per 1000 catheter-days (CI, 0.01 to 2.34 per 1000 catheter-days) for the antiseptic catheter group ($P=0.6$). Coagulase-negative staphylococci and other gram-positive organisms were the most frequent microbes to colonize catheters. Noninfectious adverse events were similar in both groups. Antiseptic susceptibility was similar for microbes recovered from either group.	1
19. Darouiche RO, Raad, II, Heard SO, et al. A comparison of two antimicrobial-impregnated central venous catheters. Catheter Study Group. *N Engl J Med.* 1999;340(1):1-8.	Experimental-Tx	738 catheters	To compare catheters impregnated with minocycline and rifampin with those impregnated with chlorhexidine and silver sulfadiazine in terms of the rates of colonization of catheters and bloodstream infection.	Of 865 catheters inserted, 738 (85%) produced culture results that could be evaluated. The clinical characteristics of the patients and the risk factors for infection were similar in the 2 groups. Catheters impregnated with minocycline and rifampin were one-third as likely to be colonized as catheters impregnated with chlorhexidine and silver sulfadiazine (28/356 catheters [7.9%] vs 87/382 [22.8%], $P<0.001$), and CRBSI was 1/12 as likely in catheters impregnated with minocycline and rifampin (1/356 [0.3%], vs 13/382 [3.4%] for those impregnated with chlorhexidine and silver sulfadiazine; $P<0.002$).	1

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20. Hanna H, Benjamin R, Chatzinikolaou I, et al. Long-term silicone central venous catheters impregnated with minocycline and rifampin decrease rates of catheter-related bloodstream infection in cancer patients: a prospective randomized clinical trial. *J Clin Oncol.* 2004;22(15):3163-3171.	Experimental-Tx	356 assessable catheters: 182 minocycline and rifampin and 174 nonimpregnated	To evaluate the efficacy of long-term nontunneled silicone catheters impregnated with minocycline and rifampin in reducing CRBSIs.	Between September 1999 and May 2002, 356 assessable catheters were used: 182 minocycline and rifampin and 174 nonimpregnated. The patients' characteristics were comparable between the 2 study groups. The mean (+/- standard deviation) duration of catheterization with minocycline and rifampin catheters was comparable to that of nonimpregnated catheters (66.21 +/- 30.88 vs 63.01 +/- 30.80 days). A total of 17 CRBSIs occurred during the course of the study. Three were associated with the use of minocycline and rifampin catheters and 14 were associated with the nonimpregnated catheters, with a rate of CRBSI of 0.25 and 1.28/1,000 catheter-days, respectively (P=.003). Gram-positive cocci accounted for the majority of the organisms causing the infections. There were no allergic reactions associated with minocycline and rifampin catheters.	1
21. Bong JJ, Kite P, Wilco MH, McMahon MJ. Prevention of catheter related bloodstream infection by silver iontophoretic central venous catheters: a randomised controlled trial. *J Clin Pathol.* 2003;56(10):731-735.	Experimental-Tx	304 single lumen study catheters in 268 patients	To evaluate the efficacy of silver iontophoretic CVCs in preventing catheter related colonization and bloodstream infection among high risk patients in a tertiary hospital.	304 single lumen study catheters were inserted into 268 patients. Total duration of catheterization was 5449 days (median, 12 days/catheter). Complete data could be evaluated in 270 catheters: 128 silver iontophoretic catheters and 140 untreated catheters. 47 silver iontophoretic catheters (36.7%) were colonized compared with 48 control catheters (33.8%). 7 cases (5.5%) of CRBSI occurred in patients who received silver iontophoretic catheters, compared with 11 cases (7.7%) in patients receiving control catheters. There was no significant difference in the incidence of catheter colonization or CRBSI between silver iontophoretic and control catheters. When the duration of catheter placement was taken into consideration, Kaplan-Meier analysis showed no significant difference in the risk of CRBSI between the silver iontophoretic catheters and the untreated catheters (P=0.77).	1

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22. Corral L, Nolla-Salas M, Ibanez-Nolla J, et al. A prospective, randomized study in critically ill patients using the Oligon Vantex catheter. *J Hosp Infect.* 2003;55(3):212-219.	Experimental-Tx	206 catheters, 103 each of standard polyurethane CVC or Oligon Vantex silver CVC	To determine whether bacterial colonization and CRBSI were associated with the use of the Oligon Vantex silver catheter in critically ill patients.	In the control group (CG) 45/103 (44%) and in the silver group (SG) 30/103 (29%) were colonized or had a CRBSI (P=0.04). The SG was less likely to be colonized than the CG when the catheter remained in situ for 8 days or less (P=0.03) or over 15 days (P=0.01); a second or subsequent catheter was present in the same patient (P=0.002), or if the CVC was placed in the internal jugular vein (P=0.05). Multivariate logistic-regression showed predisposing factors for catheter colonization were jugular and femoral sites, second or subsequent catheter, and being a member of the CG. CRBSI occurred in 5 cases (four in CG). Rates of CRBSI per 1000 catheter-days in the CG were 2.8 and in the SG, 0.8 (P<0.001).	1
23. Hagau N, Studnicska D, Gavrus RL, Csipak G, Hagau R, Slavcovici AV. Central venous catheter colonization and catheter-related bloodstream infections in critically ill patients: a comparison between standard and silver-integrated catheters. *Eur J Anaesthesiol.* 2009;26(9):752-758.	Experimental-Tx	272 catheters inserted into 230 patients (141 standard and 131 silver-integrated CVCs)	To investigate colonization and infection rates of standard CVCs in comparison with the rates for silver-integrated catheters in the ICU.	There was no significant difference in the colonization rates and the colonization per 1000 catheter days between the standard and silver-integrated catheters. Using the Kaplan-Meier curves (log-rank test), there was a significant difference in the incidence of colonization and infections over time between standard and silver-integrated catheters (P<0.01 and P<0.05, respectively). Whereas standard catheters were first colonized 3 days after the insertion, silver-integrated catheters were first colonized 5 days after insertion.	1
24. O'Grady NP, Alexander M, Burns LA, et al. Summary of recommendations: Guidelines for the Prevention of Intravascular Catheter-related Infections. *Clin Infect Dis.* 2011;52(9):1087-1099.	Review/Other-Tx	N/A	To provide evidence-based recommendations for preventing intravascular CRI.	No results stated in abstract.	4

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25. Jain G, Allon M, Saddekni S, Barker JF, Maya ID. Does heparin coating improve patency or reduce infection of tunneled dialysis catheters? *Clin J Am Soc Nephrol.* 2009;4(11):1787-1790.	Observational-Tx	175 tunneled dialysis catheters placed in the internal jugular vein, including 89 heparin-coated catheters and 86 noncoated catheters	To evaluate whether heparin-coated hemodialysis catheters have fewer infections or greater cumulative survival than noncoated catheters.	The 2 patient groups were similar in demographics and clinical and catheter features. Catheter-related bacteremia occurred less frequently with heparin-coated catheters than with noncoated catheters (34% vs 60%, $P<0.001$). Cumulative catheter survival was similar in heparin-coated and noncoated catheters (HR, 0.87; 95% CI, 0.55 to 1.36; $P=0.53$). On multiple variable survival analysis including catheter type, age, sex, diabetes, coronary artery disease, peripheral vascular disease, cerebrovascular disease, catheter location, and previous catheter, only catheter location predicted cumulative catheter survival (HR, 2.03; 95% CI, 1.27 to 3.25, with the right internal jugular location being the reference group, $P=0.003$). The frequency of thrombolytic instillation was 1.8 per 1000 catheter-days in both groups.	2
26. Pierce CM, Wade A, Mok Q. Heparin-bonded central venous lines reduce thrombotic and infective complications in critically ill children. *Intensive Care Med.* 2000;26(7):967-972.	Experimental-Tx	200 patients - 97 with heparin-bonded, 103 standard	To determine whether heparin bonding reduces the incidence of catheter-related thrombosis and infection in critically ill children.	The 2 groups were comparable for age, sex, severity of illness and length of time that the catheter was in situ. Proportional hazards modelling showed that heparin bonding was associated with a significant reduction in infections (HR 0.11, $P<0.00005$). The incidence of infection was 4% and 33% in heparin-bonded and non-heparin-bonded CVLs, respectively (4/97 vs 34/103, $P<0.0005$). The incidence of thrombosis was 0% and 8% in heparin-bonded and non-heparin-bonded CVLs, respectively (0/97 vs 8/103, $P=0.006$). The number of heparin-bonded CVLs which would need to be used to avoid one episode of infection or thrombosis was 3 and 13, respectively.	1

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27. Biffi R, De Braud F, Orsi F, et al. A randomized, prospective trial of central venous ports connected to standard open-ended or Groshong catheters in adult oncology patients. *Cancer*. 2001;92(5):1204-1212.	Experimental-Tx	302 patients (150 control; 152 experimental)	To investigate valved and open-ended catheters in a randomized trial using the same type of subcutaneous port and evaluate efficacy as well as early and late complications	302 patients (99.3%) were evaluable, 150 patients in the control group and 152 in the experimental group. The median follow-up was 237 days. There was a trend toward more early complications in the experimental group (5.9%; 95% CI, 2.7%–10.9%) than in the control group (2.7%; 95% CI, 0.7%–6.7%), although the difference was not statistically significant (P=0.26). There was also a trend toward more late complications in the experimental group (17.1%; 95% CI, 11.5%–24.1%) compared with the control group (10.7%; 95% CI, 6.2%–16.7%; P=0.13), although the difference, again, was not statistically significant. The most frequent late complication was the inability to draw blood samples (12.5% in the experimental group and 2% in the control group; P<0.001). Sepsis was observed in 1 patient and in 3 patients and venous thrombosis was observed in 6 patients and in 11 patients in the experimental and control treatment groups, respectively (P=NS).	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
28. O'Dwyer H, Fotheringham T, O'Kelly P, et al. A prospective comparison of two types of tunneled hemodialysis catheters: the Ash Split versus the PermCath. *Cardiovasc Intervent Radiol.* 2005;28(1):23-29.	Experimental-Tx	69 catheters and 69 patients	To prospectively compare 2 types of hemodialysis catheter currently available: the PermCath catheter with a staggered tip design and the newer split-tip lumen style Ash Split catheter.	A total of 69 hemodialysis catheters, 33 Ash Split and 36 PermCath, were successfully inserted in the internal jugular vein (right 60, left 9) of 69 patients. Mean blood flow during dialysis (Qb) was 270.75 mL/min and 261.86 mL/hr for the Ash Split and PermCath groups respectively (P=0.27). Mean duration of catheter use was 111.7 days (range 5.4–548.9 days) and 141.2 days (range 7.0–560.9 days) in the Ash Split and PermCath groups respectively (P=0.307). Catheter failures leading to removal or exchange occurred in 20 patients: 14 in the Ash Split group and 6 in the PermCath group. Survival curves with censored endpoints (i.e., recovery, arteriovenous fistula formation, peritoneal dialysis and transplantation) showed significantly better outcome with PermCath catheters (P=0.024). There was no significant difference in ease of insertion or early complication rates.	1
29. Tal MG, Peixoto AJ, Crowley ST, Denbow N, Eliseo D, Pollak J. Comparison of side hole versus non side hole high flow hemodialysis catheters. *Hemodial Int.* 2006;10(1):63-67.	Observational-Tx	54 patients	To compare flow rates, infection rate, and survival of side hole vs non side hole hemodialysis catheters.	Catheter infection necessitating removal of the catheter occurred in 10/37 catheters with side holes and 1/17 without side holes. Infection rates per 1000 catheter days were 2.545 with side holes and 0.254 without side holes (P<0.001). Slightly improved catheter survival (P<0.05) was recorded with the non-side hole catheters. No insertion complication (e.g., air embolization, bleeding, or kinking) occurred with either catheter. One catheter without side holes had to be repositioned 5 days after insertion because of poor flows. No significant difference was recorded in mean blood flow rates between the catheters.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
30. Power A, Hill P, Singh SK, Ashby D, Taube D, Duncan N. Comparison of Tesio and LifeCath twin permanent hemodialysis catheters: the VyTes randomized trial. *J Vasc Access.* 2014;15(2):108-115.	Experimental-Tx	80 patients	To study the immediate and long-term performance and complications of 2 twin-catheter systems, the Tesio catheter and the LifeCath Twin, to inform clinical practice.	More LifeCath reached the primary endpoint (44% vs 10%, *P*=0.001) delivering a higher blood flow rates (mean 383+/-82 vs 277+/-79 mL/min, *P*<0.001). Significant differences in blood flow rates persisted until the fourth dialysis session. Rates of catheter-related bacteremia (0.40 vs 0.51/1,000 catheter days, *P*=0.7) and exit site infection were similar between groups (0.24 vs 0.09/1,000 catheter days, *P*=0.4). Overall rates of catheter dysfunction were 2.8/1,000 catheter days (95% CI 2.1-3.5), with no differences in thrombolytic lock use although the LifeCath group required more thrombolytic infusions (6 vs 0, *P*=0.01).	1
31. Clinical practice guidelines for vascular access. *Am J Kidney Dis.* 2006;48 Suppl 1:S248-273.	Review/Other-Tx	N/A	No abstract available.	No abstract available.	4
32. Isaacs JW, Millikan WJ, Stackhouse J, Hersh T, Rudman D. Parenteral nutrition of adults with a 900 milliosmolar solution via peripheral veins. *Am J Clin Nutr.* 1977;30(4):552-559.	Experimental-Tx	Phase A: 15 patients; Phase B: 11 patients	To compare the nutritional value of 3 parenteral fluids: a conventional solution (400 milliosmoles/liter, containing Na, K, and Cl in 5% glucose); the concentrated hyperalimentation solution of Dudrick (1,800 milliosmoles/liter, containing Na, K, Cl, Mg, Ca, P, and amino acids in 20% glucose); and an experimental solution (900 millisomoles/liter, containing Na, K, Cl, Mg, Ca, P, and amino acids in 6.5% glucose).	Preliminary studies showed that when 5 mg of cortisol/liter were added to P900, this fluid could be infused through peripheral veins for as long a time (average 114 hr) as P400 before local reaction necessitated changing the site. When P400 was infused in undernourished subjects without oral intake, balances of N, P, Mg, and Ca/70 kg of body weight per day were strongly negative (-4 g, -0.4 g, -6 mEq, and -0.2 g, respectively), whereas balances of K were about zero and those of Na and Cl were positive. Weight loss occurred. In the same patients, P900 containing 5 mg of cortisol/liter converted balances of N, P, Mg, and K to positive, and stimulated weight gain. Comparison of P900 (containing cortisol) and C1,800 in 3 emaciated subjects showed that the latter fluid caused a 2 to 4 times greater degree of positive balance in N, P, K, and Mg than the former. Comparison of P900 (containing cortisol) + 670-1700 cal by mouth with C1,800 in 4 undernourished subjects showed no statistically significant difference between these 2 programs.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
33. Raad I, Davis S, Becker M, et al. Low infection rate and long durability of nontunneled silastic catheters. A safe and cost-effective alternative for long-term venous access. *Arch Intern Med.* 1993;153(15):1791-1796.	Observational-Tx	340 consecutive cancer patients with 359 nontunneled Silastic CVCs	To assess the durability, cost, and infection rate of nontunneled, noncuffed Silastic CVCs.	The mean in-place duration of the catheter for the 359 nontunneled CVCs studied was 109 days (total, 39,147 days of catheter use), and the infection rate was 0.13 per 100 catheter days. When compared with the tunneled Hickman catheter, the insertion cost saving was at least $2322 per CVC. At our institution, the use of nontunneled Silastic catheters with the support of an expert infusion team has resulted in an annual cost saving of at least $7,692,000. Long peripheral CVCs (in the basilic/cephalic vein) had a 26% rate of inflammation at the insertion site compared with only 2.6% for the short subclavian CVCs ($P<.01$). Most of the exit-site inflammations were sterile, with negative skin and catheter cultures. Neutropenia, bone marrow transplantation, high-dose steroids, and use of vesicant chemotherapeutic agents through the CVC did not predispose the patients to catheter infection. By univariate analysis, acute leukemia was the only risk factor for catheter infection.	2
34. Safdar N, Maki DG. Risk of catheter-related bloodstream infection with peripherally inserted central venous catheters used in hospitalized patients. *Chest.* 2005;128(2):489-495.	Meta-analysis	115 patients in study population plus 33 studies	To determine the risk of PICC-related BSI in hospitalized patients.	Overall, 115 patients had 251 PICCs placed. Mean duration of catheterization was 11.3 days (total, 2832 PICC-days); 42% of the patients were in an ICU at some time, 62% had urinary catheters, and 49% had received mechanical ventilation. 6 PICC-related BSIs were identified (2.4%), 4 with coagulase-negative staphylococcus, 1 with Staphylococcus aureus, and 1 with Klebsiella pneumoniae, a rate of 2.1 per 1000 catheter-days.	M
35. Ryder MA. Peripheral access options. *Surg Oncol Clin N Am.* 1995;4(3):395-427.	Review/Other-Tx	N/A	To evaluate peripheral access devices as first-line alternatives to improve patient outcomes in the delivery of parenteral therapy.	No results stated in abstract.	4
36. Ryder M. Evidence-based practice in the management of vascular access devices for home parenteral nutrition therapy. *JPEN J Parenter Enteral Nutr.* 2006;30(1 Suppl):S82-93, S98-89.	Review/Other-Tx	N/A	To review the evidence for implementation of critical preventative strategies linked to the pathogenesis of the most common VAD complications, CRI and thrombotic catheter occlusion.	No results states in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
37. Barton AJ, Danek G, Johns P, Coons M. Improving patient outcomes through CQI: vascular access planning. *J Nurs Care Qual.* 1998;13(2):77-85.	Experimental-Tx	297 patients	To report the use of the continuous quality improvement process to improve patient outcomes.	An evaluation study revealed that patients whose vascular access planning was consistent with the algorithm reported fewer i.v.s, less difficulty starting i.v.s, and less stress; waited significantly less time until CVL placement (for those who received CVLs); and had significantly shorter lengths of stay.	2
38. Maki DG, Kluger DM, Crnich CJ. The risk of bloodstream infection in adults with different intravascular devices: a systematic review of 200 published prospective studies. *Mayo Clin Proc.* 2006;81(9):1159-1171.	Meta-analysis	200 studies	To better understand the absolute and RRs of BSI associated with the various types of intravascular devices by analyzing 200 published studies of adults in which every device in the study population was prospectively evaluated for evidence of associated infection and microbiologically based criteria were used to define intravascular device-related BSI.	Point incidence rates of intravascular device-related BSI were lowest with peripheral intravenous catheters (0.1%, 0.5 per 1000 intravascular device-days) and midline catheters (0.4%, 0.2 per 1000 catheter-days). Far higher rates were seen with short-term noncuffed and nonmedicated CVCs (4.4%, 2.7 per 1000 catheter-days). Arterial catheters used for hemodynamic monitoring (0.8%, 1.7 per 1000 catheter-days) and peripherally inserted central catheters used in hospitalized patients (2.4%, 2.1 per 1000 catheter-days) posed risks approaching those seen with short-term conventional CVCs used in the ICU. Surgically implanted long-term central venous devices–cuffed and tunneled catheters (22.5%, 1.6 per 1000 intravascular device-days) and central venous ports (3.6%, 0.1 per 1000 intravascular device-days)–appear to have high rates of Infection when risk is expressed as BSIs per 100 intravascular devices but actually pose much lower risk when rates are expressed per 1000 intravascular device-days. The use of cuffed and tunneled dual lumen CVCs rather than noncuffed, nontunneled catheters for temporary hemodialysis and novel preventive technologies, such as CVCs with anti-infective surfaces, was associated with considerably lower rates of catheter-related BSI.	M

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
39. Bow EJ, Kilpatrick MG, Clinch JJ. Totally implantable venous access ports systems for patients receiving chemotherapy for solid tissue malignancies: A randomized controlled clinical trial examining the safety, efficacy, costs, and impact on quality of life. *J Clin Oncol.* 1999;17(4):1267.	Experimental-Tx	199 assessable patients	To examine the safety, efficacy, costs, and impact on quality of life of venous access ports implanted at the outset of a course of intravenous cancer chemotherapy.	Port complication rates were low (0.23/1,000 days). Failure occurred in 2 (3.4%) of 59 port subjects and 16 (26.7%) of 60 controls (*P*=.0004) at a median period of 26 days after randomization (95% CI, 8 to 92). Peripheral accesses in port subjects took less time, had less access-related anxiety and pain, and were less costly to perform than in controls. Allocation had no effect on Functional Living Index-Cancer scores. Peripheral access failure correlated with allocation to the control group (*P*=.007), higher pain scores with intravenous starts (*P*=.003), and anxiety with intravenous starts (*P*=.01). Venous accessing overall in port patients was 4 times more costly than that in controls ($2,178/patient vs $530/patient, respectively).	1
40. Kuriakose P, Colon-Otero G, Paz-Fumagalli R. Risk of deep venous thrombosis associated with chest versus arm central venous subcutaneous port catheters: a 5-year single-institution retrospective study. *J Vasc Interv Radiol.* 2002;13(2 Pt 1):179-184.	Observational-Tx	440 implantable chest or arm ports in 422 patients	To determine the risk of DVT in patients undergoing placement of central (chest) vs peripheral (arm) ports.	In 273 chest ports placed, there were 13 (4.8%) instances of DVT; in 149 peripheral ports, there were 17 (11.4%). Censoring data on patients receiving some form of anticoagulation, the respective incidences were 8/245 (3.3%) and 14/129 (10.9%). With use of Kaplan-Meier analysis and log-rank tests to examine comparisons of interest, the probability of thrombosis occurring over a period of 180 days was higher with peripheral ports irrespective of Coumadin use (*P*=.007 for all patients considered, *P*=.002 when analyzed only for those not receiving Coumadin). The difference in incidence of thrombosis for all ports between patients receiving Coumadin vs those not receiving Coumadin was not significant.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
41. Patel GS, Jain K, Kumar R, et al. Comparison of peripherally inserted central venous catheters (PICC) versus subcutaneously implanted port-chamber catheters by complication and cost for patients receiving chemotherapy for non-haematological malignancies. *Support Care Cancer.* 2014;22(1):121-128.	Experimental-Tx	70 patients	To compare the safety and cost of 2 commonly used CVCs, PICCs and ports, in the delivery of chemotherapy in patients with nonhematologic malignancies.	Port devices were associated with fewer complications compared with PICC lines (HR of 0.25, CI, 0.09–0.86, *P*=0.038). Major complication rate was lower in the port arm compared to the PICC arm (0.047 vs 0.193 major complications/100 catheter days, *P*=0.034) with 6% vs 20% of patients experiencing major complications, respectively. Thrombosis, the most common complication, was significantly higher in the PICC arm compared to the port arm (25% vs 0%, *P*=0.013). Quality of life and cost estimates did not differ significantly between the 2 arms.	1
42. Kulkarni S, Wu O, Kasthuri R, Moss JG. Centrally inserted external catheters and totally implantable ports for the delivery of chemotherapy: a systematic review and meta-analysis of device-related complications. *Cardiovasc Intervent Radiol.* 2014;37(4):990-1008.	Meta-analysis	5 RCTs and 25 observational studies	To evaluate the risks of complications (infectious and noninfectious) including the need for device removal associated with centrally inserted external catheters compared with totally implantable ports in patients undergoing chemotherapy.	Overall, 5 RCTs and 25 observational studies were included in the study. The studies were heterogeneous, and included adults and children, with different types of cancer, undergoing chemotherapy. Based on the pooled estimates from included studies, external catheters were associated with approximately a three to four-fold increase in the risks of infections, noninfectious complications and device removal compared implantable ports.	M

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
43. Garnacho-Montero J, Aldabo-Pallas T, Palomar-Martinez M, et al. Risk factors and prognosis of catheter-related bloodstream infection in critically ill patients: a multicenter study. *Intensive Care Med.* 2008;34(12):2185-2193.	Observational-Tx	1,366 patients, 2,101 catheters	To assess the risk factors associated with CRBSI development in critically ill patients with non-tunneled, non-cuffed CVCs and the prognosis of the episodes of CRBSI. Design and setting; prospective, observational, multicenter study in nine Spanish Hospitals.	Overall, 1,366 patients were enrolled and 2,101 catheters were analyzed. 66 episodes of CRBSI were diagnosed. The incidence of CRBSI was significantly higher in CVC compared with PICC without significant differences among the 3 locations of CVC. In the multivariate analysis, duration of catheterization and change over a guidewire were the independent variables associated with the development of CRBSI whereas the use of a PICC was a protective factor. Excluding PICC, 1,598 conventional CVC were analyzed. In this subset, duration of catheterization, tracheostomy and change over a guidewire were independent risk factors for CRBSI. A multivariate analysis of predictors for mortality among 66 patients with CRSI showed that early removal of the catheter was a protective factor and APACHE II score at the admission was a strong determinant of in-hospital mortality.	2
44. Turcotte S, Dube S, Beauchamp G. Peripherally inserted central venous catheters are not superior to central venous catheters in the acute care of surgical patients on the ward. *World J Surg.* 2006;30(8):1605-1619.	Review/Other-Tx	48 studies	To compare the associated infectious, thrombotic, phlebitic, and other common complications, as well as PICC and CVC durability.	Our results show that infectious complications do not significantly differ between PICC and CVC. Thrombotic complications appear to be more significant with PICC and to occur early after catheterization. Phlebitic complications accounted for premature catheter removal in approximately 6% of PICC. Finally, prospective data suggest that approximately 40% of PICC will have to be removed before completion of therapy, possibly more often and earlier than CVC.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
45. Goetz AM, Wagener MM, Miller JM, Muder RR. Risk of infection due to central venous catheters: effect of site of placement and catheter type. *Infect Control Hosp Epidemiol.* 1998;19(11):842-845.	Observational-Tx	300 catheters in 204 patients	To determine the influence of catheter site and type (single- vs triple-lumen) on infection rates associated with central venous catheterization.	300 catheters were inserted into 204 patients. 70% were inserted into upper-body sites, and 30% were inserted into the femoral vein. 45% were triple-lumen catheters. Bacteremia occurred in 2.7% of catheter insertions; insertion-site infections developed in 1.3%, and catheter colonization developed in 12%. Catheter contamination was associated with emergent insertion (OR, 6.2; 95% CI, 1.1–36.7; *P*=.04) by logistic regression and with femoral location (HR, 4.2; 95% CI, 2.0–8.8; *P*=.0001) and history of transplantation (HR, 2.8; 95% CI, 1.1–6.7; *P*=.024) by Cox regression. Clinical infection was not associated with any of the risk factors evaluated, although there was a trend for association with femoral location by Cox regression (HR, 4.7; 95% CI, 0.82–26; *P*=.08). We did not identify an association between infection and use of triple-lumen catheters or parenteral nutrition.	2
46. Lorente L, Henry C, Martin MM, Jimenez A, Mora ML. Central venous catheter-related infection in a prospective and observational study of 2,595 catheters. *Crit Care.* 2005;9(6):R631-635.	Observational-Tx	2,018 patients	To analyze the incidence of catheter-related local infection and CRBSI with CVCs according to different access sites.	The study included 2,018 patients. The number of CVCs and days of catheterization duration were: global, 2,595 and 18,999; subclavian, 917 and 8,239; jugular, 1,390 and 8,361; femoral, 288 and 2,399. Catheter-related local infection incidence density was statistically higher for femoral than for jugular (15.83 vs 7.65, *P*<0.001) and subclavian (15.83 vs 1.57, *P*<0.001) accesses, and higher for jugular than for subclavian access (7.65 vs 1.57, *P*<0.001). CRBSI incidence density was statistically higher for femoral than for jugular (8.34 vs 2.99, *P*=0.002) and subclavian (8.34 vs 0.97, *P*<0.001) accesses, and higher for jugular than for subclavian access (2.99 vs 0.97, *P*=0.005).	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
47. Merrer J, De Jonghe B, Golliot F, et al. Complications of femoral and subclavian venous catheterization in critically ill patients: a randomized controlled trial. *JAMA*. 2001;286(6):700-707.	Experimental-Tx	293 patients	To compare mechanical, infectious, and thrombotic complications of femoral and subclavian venous catheterization.	Femoral catheterization was associated with a higher incidence rate of overall infectious complications (19.8% vs 4.5%; *P*<.001; incidence density of 20 vs 3.7 per 1000 catheter-days) and of major infectious complications (clinical sepsis with or without bloodstream infection, 4.4% vs 1.5%; *P*=.07; incidence density of 4.5 vs 1.2 per 1000 catheter-days), as well as of overall thrombotic complications (21.5% vs 1.9%; *P*<.001) and complete thrombosis of the vessel (6% vs 0%; *P*=.01); rates of overall and major mechanical complications were similar between the 2 groups (17.3% vs 18.8 %; *P*=.74 and 1.4% vs 2.8%; *P*=.44, respectively). Risk factors for mechanical complications were duration of insertion (OR, 1.05; 95% CI, 1.03–1.08 per additional minute; *P*<.001); insertion in 2 of the centers (OR, 4.52; 95% CI, 1.81–11.23; *P*=.001); and insertion during the night (OR, 2.06; 95% CI, 1.04–4.08; *P*=.03). The only factor associated with infectious complications was femoral catheterization (HR, 4.83; 95% CI, 1.96–11.93; *P*<.001); antibiotic administration via the catheter decreased risk of infectious complications (HR, 0.41; 95% CI, 0.18–0.93; *P*=.03). Femoral catheterization was the only risk factor for thrombotic complications (OR, 14.42; 95% CI, 3.33–62.57; *P*<.001).	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
48. Trottier SJ, Veremakis C, O'Brien J, Auer AI. Femoral deep vein thrombosis associated with central venous catheterization: results from a prospective, randomized trial. *Crit Care Med.* 1995;23(1):52-59.	Experimental-Tx	45 patients	To determine the frequency of CVC-induced DVT of the femoral vein.	Of the 21 patients randomized to upper access sites, none developed positive or nondiagnostic duplex US examinations. 6 (25%) of 24 patients randomized to the femoral access site developed lower extremity DVT (P=.02). In addition, 7 (29%) patients randomized to the lower access site sustained nondiagnostic US examinations. A total of 13 (54%) of 24 patients from the lower access group developed abnormal US examinations (P<.001). Age, duration of catheterization, coagulation profile, DVT prophylaxis, and Acute Physiology and Chronic Health Evaluation II scores were similar between the upper and lower access groups.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
49. Ge X, Cavallazzi R, Li C, Pan SM, Wang YW, Wang FL. Central venous access sites for the prevention of venous thrombosis, stenosis and infection. *Cochrane Database Syst Rev.* 2012;3:CD004084.	Meta-analysis	4 studies; 1513 participants	To establish whether the jugular, subclavian or femoral CVA routes resulted in a lower incidence of venous thrombosis, venous stenosis or infections related to CVA devices in adult patients, and to assess whether the jugular, subclavian or femoral CVA routes influenced the incidence of catheter-related mechanical complications in adult patients; and the reasons why patients left the studies early.	We identified 5854 citations from the initial search strategy; 28 references were then identified as potentially relevant. Of these, we Included 4 studies with data from 1513 participants. We undertook a priori subgroup analysis according to the duration of catheterization, short-term (<1 month) and long-term (>1 month) defined according to the FDA. No randomized controlled trial was found comparing all 3 CVA routes and reporting the complications of venous stenosis. Regarding internal jugular vs subclavian CVA routes, the evidence was moderate and applicable for long-term catheterization in cancer patients. Subclavian and internal jugular CVA routes had similar risks for catheter-related complications. Regarding femoral vs subclavian CVA routes, the evidence was high and applicable for short-term catheterization in critically ill patients. Subclavian CVA routes were preferable to femoral CVA routes in short-term catheterization because femoral CVA routes were associated with higher risks of catheter colonization (14.18% or 19/134 vs 2.21% or 3/136) (n = 270, 1 randomized controlled trial, RR 6.43, 95% CI, 1.95 to 21.21) and thrombotic complications (21.55% or 25/116 vs 1.87% or 2/107) (n = 223, 1 randomized controlled trial, RR 11.53, 95% CI, 2.80 to 47.52) than with subclavian CVA routes. Regarding femoral vs internal jugular routes, the evidence was moderate and applicable for short-term hemodialysis catheterization in critically ill patients. No significant differences were found between femoral and internal jugular CVA routes in catheter colonization, CRBSI and thrombotic complications, but fewer mechanical complications occurred in femoral CVA routes (4.86% or 18/370 vs 9.56% or 35/366) (n = 736, 1 randomized controlled trial, RR 0.51, 95% CI, 0.29 to 0.88).	M

Radiologic Management of Central Venous Access
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
50. Parienti JJ, Mongardon N, Megarbane B, et al. Intravascular Complications of Central Venous Catheterization by Insertion Site. *N Engl J Med.* 2015;373(13):1220-1229.	Experimental-Tx	3,471 catheters in 3,027 patients	To evaluate the risk of CRBSI or symptomatic catheter-related DVT in adult patients who had been admitted to an ICU.	A total of 3471 catheters were inserted in 3027 patients. In the three-choice comparison, there were 8, 20, and 22 primary outcome events in the subclavian, jugular, and femoral groups, respectively (1.5, 3.6, and 4.6 per 1000 catheter-days; *P*=0.02). In pairwise comparisons, the risk of the primary outcome was significantly higher in the femoral group than in the subclavian group (HR, 3.5; 95% CI, 1.5 to 7.8; *P*=0.003) and in the jugular group than in the subclavian group (HR, 2.1; 95% CI, 1.0 to 4.3; *P*=0.04), whereas the risk in the femoral group was similar to that in the jugular group (HR, 1.3; 95% CI, 0.8 to 2.1; *P*=0.30). In the three-choice comparison, pneumothorax requiring chest-tube insertion occurred in association with 13 (1.5%) of the subclavian-vein insertions and 4 (0.5%) of the jugular-vein insertions.	1
51. Biffi R, Orsi F, Pozzi S, et al. Best choice of central venous insertion site for the prevention of catheter-related complications in adult patients who need cancer therapy: a randomized trial. *Ann Oncol.* 2009;20(5):935-940.	Experimental-Tx	401 patients	To compare 2 different percutaneous routes of access to superior vena cava (subclavian and internal jugular) with a surgical cut-down access through the cephalic vein, evaluating early and late complications, including pneumothorax, clinically relevant bleeding, primary malposition, port-related bacteremia, pocket infections, late dislocation, fibrin sleeve formation, malfunction of the device, extravasation, clinically evident and silent venous thrombosis at any time.	401patients (99.9%) were assessable: 132 with the internal jugular, 136 with the subclavian and 133 with the cephalic vein access. The median follow-up was 356.5 days (range 0–1087). No differences were found for early complication rate in the 3 groups {internal jugular: 0% [95% CI, 0.0% to 2.7%], subclavian: 0% (95% CI, 0.0% to 2.7%), cephalic: 1.5% (95% CI, 0.1% to 5.3%)}. US-guided subclavian insertion site had significantly lower failures (eg, failed attempts to place the catheter in agreement with the original arm of randomization, *P*=0.001). Infections occurred in 1, 3 and 1 patients (internal jugular, subclavian and cephalic access, respectively, *P*=0.464), whereas venous thrombosis was observed in 15, 8 and 11 patients (*P*=0.272).	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
52. McBride KD, Fisher R, Warnock N, Winfield DA, Reed MW, Gaines PA. A comparative analysis of radiological and surgical placement of central venous catheters. *Cardiovasc Intervent Radiol.* 1997;20(1):17-22.	Observational-Tx	253 Hickman catheters in 209 patients	To compare the differences in practice and outcome of all radiologically and surgically placed CVCs retrospectively over a 2-year period simultaneously, at a single institution.	There were 6 (4.5%) primary surgical failures and a further 17 (13%) surgical cases requiring multiple placement attempts. Pneumothorax occurred once (0.8%) surgically and 4 times (3.3%) radiologically. There were no radiological primary misplacements but there were 5 (3.7%) surgical ones. Catheter or central vein thrombosis occurred in 4 (3.3%) radiological and 5 (3.7%) surgical cases. The rate of infection per 1000 catheter-days was 1.9 in radiologically placed catheters and 4.0 in surgically placed ones ($P<0.001$). Average catheter life-span was similar for the 2 placement methods (100 +/- 23 days).	2
53. Cimochowski GE, Worley E, Rutherford WE, Sartain J, Blondin J, Harter H. Superiority of the internal jugular over the subclavian access for temporary dialysis. *Nephron.* 1990;54(2):154-161.	Observational-Tx	52 patients with 85 catheters	To ascertain the occurrence and severity of this potential complication, i.e. late strictures of the subclavian vein following temporary catheter dialysis via the subclavian or internal jugular route.	The 2 groups were statistically similar with respect to age, sex and race. The subclavian catheters were left in for a mean of 11.5 days (2–22) while the internal jugular ones were inserted for 15.8 days (5–25; $P=0.0015$). 100% of the internal jugular patients were free of any venogram abnormalities in their venous access return. In marked contrast, 50% of the subclavian sites had mild to severe stricutures with 90% having 70%–100% occlusion of the subclavian vein. 6 patients had bilateral severe strictures.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
54. Funaki B, Zaleski GX, Leef JA, Lorenz JN, Van Ha T, Rosenblum JD. Radiologic placement of tunneled hemodialysis catheters in occluded neck, chest, or small thyrocervical collateral veins in central venous occlusion. *Radiology.* 2001;218(2):471-476.	Experimental-Tx	24 patients; 25 catheters	To evaluate interventional radiologic placement of tunneled hemodialysis catheters in small thyrocervical collateral veins or in occluded veins in the neck or chest in patients with limited venous access.	Technical success was achieved in 22 (88%) of 25 procedures (1 patient underwent 2 procedures). All catheters functioned immediately after placement. There were 2 procedural complications: a vasovagal episode requiring intravenously administered atropine sulfate and an episode of respiratory distress requiring intubation. There were no instances of pneumothorax, nerve injury, or bleeding complications. Catheter malfunction requiring exchange occurred at a rate of 0.67 per 100 catheter days. Infection requiring catheter removal occurred at a rate of 0.06 per 100 catheter days. Primary patency was 90% at 1 month, 71% at 6 months, and 25% at 12 months. Secondary patency was 100% at 6 months and 70% at 12 months.	2
55. Lund GB, Trerotola SO, Scheel PJ, Jr. Percutaneous translumbar inferior vena cava cannulation for hemodialysis. *Am J Kidney Dis.* 1995;25(5):732-737.	Experimental-Tx	17 double-lumen hemodialysis catheters in 12 patients	To evaluate the percutaneous translumbar approach for long-term hemodialysis catheter access.	Catheter placement was successful in all patients. Adequate flow rates were obtained. 7 episodes of thrombosis-related access failure occurred (0.33 episodes/100 days at risk). 2 catheters were removed and 5 catheters were managed with urokinase infusion. 6 episodes of infection occurred (0.28 episodes/100 days at risk). 4 required catheter removal. 2 catheters were removed after defects developed in the catheter. 5 catheters were removed electively because catheter hemodialysis was discontinued. 4 catheters remained in place. Cumulative patency was 52% at 6 months and 17% at 12 months.	2
56. Stavropoulos SW, Pan JJ, Clark TW, et al. Percutaneous transhepatic venous access for hemodialysis. *J Vasc Interv Radiol.* 2003;14(9 Pt 1):1187-1190.	Observational-Tx	36 catheters in 12 patients	To examine our experience, including clinical follow-up with transhepatic hemodialysis catheters in patients in whom more traditional venous access sites have been exhausted.	21 catheters were replaced or removed because of catheter thrombosis, yielding a catheter thrombosis rate of 2.40 per 100 catheter-days. The line sepsis rate was 0.22 per 100 catheter-days. Poor patency rates were seen because of a high rate of late thrombosis.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
57. Skoutelis AT, Murphy RL, MacDonell KB, VonRoenn JH, Sterkel CD, Phair JP. Indwelling central venous catheter infections in patients with acquired immune deficiency syndrome. *J Acquir Immune Defic Syndr.* 1990;3(4):335-342.	Observational-Tx	299 patients: 54 AIDS, 102 non-AIDS immunodeficiencies, 98 immunocompetent	To evaluate the risk of catheter infection in patients with AIDS.	The rate of infection per 1,000 catheter days was 2.02, 0.41 (P<0.002), and 0.23 (P<0.002), respectively. Gram-positive cocci were the predominant isolate. Previous catheter infection and advanced AIDS (as determined by positive p24 antigen and low CD4+ number) were associated with increased risk of infection. Exit, tunnel, and fungal infections required catheter removal. The risk of infection and management were similar in Hickman and Port-a-cath catheters. The mortality was extremely low in all groups. However, the risk of infection associated with indwelling catheters was significantly higher in AIDS patients compared to patients with other immunodeficiencies.	2
58. Riikonen P, Saarinen UM, Lahteenoja KM, Jalanko H. Management of indwelling central venous catheters in pediatric cancer patients with fever and neutropenia. *Scand J Infect Dis.* 1993;25(3):357-364.	Observational-Tx	97 episodes	To detect factors, if any, that would favor keeping or removing the CVL during a septic episode.	The need for catheter removal during a febrile infection was 0.32/1000 catheter days, and the documented sepsis rate was 0.59/1000 catheter days. Our data indicate that 94% of episodes of fever and neutropenia in total, 78% of documented septicemias, and 97% of fevers of unknown origin were curable with broad-coverage antimicrobial therapy without removing the CVL.	2
59. Freire MP, Pierrotti LC, Zerati AE, et al. Infection related to implantable central venous access devices in cancer patients: epidemiology and risk factors. *Infect Control Hosp Epidemiol.* 2013;34(7):671-677.	Observational-Tx	966 CVADs (mostly venous ports) in 933 patients	To describe the epidemiology of infections related to the use of implantable CVADs in cancer patients and to evaluate measures aimed at reducing the rates of such infections.	During the study period, 966 CVADs (mostly venous ports) were implanted in 933 patients, for a combined total of 243,792 catheter-days. We identified 184 episodes of infection: 154 (84%) were bloodstream infections, 21 (11%) were pocket infections, and 9 (5%) were surgical site infections. During the study period, the rate of CVAD-related infection dropped from 2.2 to 0.24 per 1,000 catheter-days. Multivariate analysis revealed that relevant risk factors for such infection include surgical reintervention, implantation in a neutropenic patient, in-hospital implantation, use of a cuffed catheter, and nonchemotherapy indication for catheter use.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
60. Balestreri L, De Cicco M, Matovic M, Coran F, Morassut S. Central venous catheter-related thrombosis in clinically asymptomatic oncologic patients: a phlebographic study. *Eur J Radiol.* 1995;20(2):108-111.	Observational-Tx	57 patients	To evaluate the incidence of axillary-subclavian vein thrombosis in cancer patients with CVC and without clinical symptoms of venous obstruction.	Different degrees of incomplete thrombosis were found in 26 patients (45.5%) and complete thrombosis, clinically silent, was found in 6 patients (10.5%). A fibrin sleeve around the CVC was radiologically demonstrated in 45 (78%) patients, 21 of them (46%) with negative standard venogram. Only in 4 patients there was no evidence of fibrin sleeve or parietal thrombosis. There were no significant differences between patients with long-term and short-term CVCs.	2
61. Bern MM, Lokich JJ, Wallach SR, et al. Very low doses of warfarin can prevent thrombosis in central venous catheters. A randomized prospective trial. *Ann Intern Med.* 1990;112(6):423-428.	Experimental-Tx	82 patients	To determine whether very low doses of warfarin are useful in thrombosis prophylaxis in patients with CVCs.	121 patients entered the study, and 82 patients completed the study. Of 42 patients completing the study while receiving warfarin, 4 had venogram-proven thrombosis. All 4 had symptoms from thrombosis. Of 40 patients completing the study while not receiving warfarin, 15 had venogram-proven thrombosis, and 10 had symptoms from thrombosis ($P<0.001$). There were no measurable changes in the coagulation values assayed due to this warfarin dose, except in occasional patients who had become anorectic because of their disease or chemotherapy.	1
62. De Cicco M, Matovic M, Balestreri L, et al. Central venous thrombosis: an early and frequent complication in cancer patients bearing long-term silastic catheter. A prospective study. *Thromb Res.* 1997;86(2):101-113.	Observational-Tx	95 patients	To evaluate prevalence, timing and evolution of thrombosis, and identify involved veins and risk factors in cancer patients undergoing percutaneous subclavian CVC for chemotherapy, parenteral nutrition or both.	Catheter-related CVT was observed in 63/95 (66%) patients. At day 8, 30 and 105 (representing the median days in which first, second and last phlebography were performed) catheter-related CVT was evidenced in 64%, 65% and 66% of the patients, respectively. Thrombus grading did not differ among first, second and last phlebography. Catheter-related CVT was symptomatic in 4/63 (6%) patients. Thrombosis prevalence was higher in subclavian (97%) with respect to innominate (60%) or cava (13%) veins ($P<0.001$). Thrombosis was higher in left subclavian catheters (14/16; 87.5%) than in right ones (49/79; 62%), $P<0.01$. No associations were established between catheter-related CVT and other investigated parameters.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
63. Monreal M, Alastrue A, Rull M, et al. Upper extremity deep venous thrombosis in cancer patients with venous access devices--prophylaxis with a low molecular weight heparin (Fragmin). *Thromb Haemost.* 1996;75(2):251-253.	Experimental-Tx	32 patients	To investigate the effectiveness of low doses of Fragmin in preventing catheter-related DVT; and to try to confirm if patients with high platelet counts are at a higher risk to develop subclavian DVT, as previously suggested.	DVT developed in 1/16 patients (6%) taking Fragmin and 8/13 patients (62%) without prophylaxis (RR 6.75; 95% CI, 1.05–43.58; *P*=0.002, Fisher exact test). No bleeding complications had developed. As for prediction of DVT, there was a tendency towards a higher platelet count in those patients who subsequently developed DVT, but differences failed to reach any statistical significance (286 +/- 145 vs 207 +/- 81 x 10(9)/1; *P*=0.067).	1
64. Sola JE, Stone MM, Wise B, Colombani PM. Atypical thrombotic and septic complications of totally implantable venous access devices in patients with cystic fibrosis. *Pediatr Pulmonol.* 1992;14(4):239-242.	Review/Other-Tx	22 infusaports in 15 cystic fibrosis patients	To report our experience over a 6-year period with the use of infusaports in children and adults with cystic fibrosis.	The overall complication rate was relatively low, 1 in every 1,483 catheter days. Infectious complications were extremely infrequent at a rate of 1 in 5,929 catheter days. The rate of mechanical complications was 1 in 1,976 catheter days. However, superior vena caval syndrome or DVT was associated with 3 of 22 catheters (13.6%).	4
65. Verso M, Agnelli G. Venous thromboembolism associated with long-term use of central venous catheters in cancer patients. *J Clin Oncol.* 2003;21(19):3665-3675.	Review/Other-Tx	N/A	To review the epidemiology, pathogenesis, diagnosis, prevention, and treatment of VTE in cancer patients with long-term CVC.	No results stated in abstract.	4
66. Jacobs BR. Central venous catheter occlusion and thrombosis. *Crit Care Clin.* 2003;19(3):489-514, ix.	Review/Other-Tx	N/A	To review the background, pathophysiology, and incidence of catheter occlusion and catheter-related thrombosis.	No results stated in abstract.	4
67. Stephens LC, Haire WD, Kotulak GD. Are clinical signs accurate indicators of the cause of central venous catheter occlusion? *JPEN J Parenter Enteral Nutr.* 1995;19(1):75-79.	Observational-Tx	200 catheters in 172 patients	To objectively identify thrombotic occlusions as the cause of catheter dysfunction.	Catheter type and duration of placement were not significant factors for predicting the type of dysfunction. Failure to withdraw blood was associated with 96% of the thrombosed catheters; this was also associated with 65% of the catheters with nonthrombotic dysfunctions. Once the cause of catheter occlusion was correctly identified, 90% of the catheters were restored to normal function.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
68. van Rooden CJ, Molhoek SG, Rosendaal FR, Schalij MJ, Meinders AE, Huisman MV. Incidence and risk factors of early venous thrombosis associated with permanent pacemaker leads. *J Cardiovasc Electrophysiol.* 2004;15(11):1258-1262.	Observational-Tx	145 patients	To assess the incidence of thrombosis, the contribution of established thrombotic risk factors, and the clinical outcome of thrombosis associated with permanent pacemaker leads.	Thrombosis was observed in 34 (23%) of 145 patients. Thrombosis did not cause any signs or symptoms in 31 patients but resulted in overt clinical symptoms in 3 patients. The absence of anticoagulant therapy, use of hormone therapy, and a personal history of venous thrombosis were associated with an increased risk of thrombosis. The risk of thrombosis increased in the presence of multiple pacemaker leads compared to a single lead.	1
69. Di Nisio M, Van Sluis GL, Bossuyt PM, Buller HR, Porreca E, Rutjes AW. Accuracy of diagnostic tests for clinically suspected upper extremity deep vein thrombosis: a systematic review. *J Thromb Haemost.* 2010;8(4):684-692.	Review/Other-Dx	17 articles with 793 patients; 2 independent reviewers	Systematic review was performed to assess whether the diagnostic accuracy of other tests for clinically suspected UEDVT is high enough to justify their use in clinical practice and to evaluate if any test can replace venography.	Sensitivity (95% CI) was 97% (90%–100%) for compression US, 84% (72%–97%) for Doppler US, 91% (85%–97%) for Doppler US with compression, and 85% (72%–99%) for phleboreography. The corresponding summary estimates of specificity were, respectively, 96% (87%–100%), 94% (86%–100%), 93% (80%–100%), and 87% (71%–100%). Clinical findings, a clinical score, D-dimer, MRI, rheography and plethysmography were evaluated in 1 study each, involving a median number of 46 patients (range 21–214). Sensitivity and specificity ranged from 0% to 100% and from 14% to 100%. Methodological limitations, large between-study differences and small sample sizes limit the evidence of tests for clinically suspected UEDVT. Compression US may be an acceptable alternative to venography. The addition of (color) Doppler does not seem to improve the accuracy. Adequately designed studies are warranted to confirm these findings.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
70. Elman EE, Kahn SR. The post-thrombotic syndrome after upper extremity deep venous thrombosis in adults: a systematic review. *Thromb Res.* 2006;117(6):609-614.	Review/Other-Tx	7 studies	To perform a systematic review of clinical studies that have examined the incidence, clinical features, risk factors and management of post-thrombotic syndrome after UEDVT.	7 studies were reviewed. The frequency of post-thrombotic syndrome after UEDVT ranges from 7%–46% (weighted mean 15%). Residual thrombosis and axillosubclavian vein thrombosis appear to be associated with an increased risk of post-thrombotic syndrome, whereas catheter-associated UEDVT may be associated with a decreased risk. There is currently no validated, standardized scale to assess upper extremity post-thrombotic syndrome, and little consensus regarding the optimal management of this condition. Quality of life is impaired in patients with upper extremity post-thrombotic syndrome, especially after DVT of the dominant arm.	4
71. Hingorani A, Ascher E, Marks N, et al. Morbidity and mortality associated with brachial vein thrombosis. *Ann Vasc Surg.* 2006;20(3):297-300.	Review/Other-Dx	598 patients	To analyze the mortality and incidence of PE diagnosed with subclavian/axillary/internal jugular vein thrombosis during an 11-year period at our institution and compare the data to those of patients diagnosed with brachial DVT.	Mortality rates at 2 months were 29%, 25%, and 21% for each group, respectively. The number of patients diagnosed with PE by ventilation/perfusion scans in groups I, II, and III, respectively, were 5%, 6.25% and 11.5% (P=0.13). Furthermore, stratification by risk factors failed to demonstrate factors associated with increased 2-month mortality. Contrary to the initial hypothesis of a relationship between the site of thrombosis and the incidence of PE and mortality, these data demonstrated no statistical differences in mortality or incidence of PE among the groups studied. Additionally, these data suggest that brachial vein thrombosis is a disease process related to comparable associated mortality and morbidity similar to other forms of UEDVT.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
72. Martinelli I, Battaglioli T, Bucciarelli P, Passamonti SM, Mannucci PM. Risk factors and recurrence rate of primary deep vein thrombosis of the upper extremities. *Circulation.* 2004;110(5):566-570.	Review/Other-Dx	115 patients	To investigate the role of potential risk factors and to evaluate the recurrence rate after a period of anticoagulant therapy in a large series of patients with primary UEDVT.	Recurrent UEDVT was evaluated prospectively over a median of 5.1 years of follow-up. The adjusted OR for UEDVT was 6.2 (95% CI, 2.5 to 15.7) for factor V Leiden, 5.0 (95% CI, 2.0 to 12.2) for prothrombin G20210A, and 4.9 (95% CI, 1.1 to 22.0) for the anticoagulant protein deficiencies. Hyperhomocysteinemia and oral contraceptives were not associated with UEDVT. However, in women with factor V Leiden or prothrombin G20210A who were taking oral contraceptives, the OR for UEDVT was increased up to 13.6 (95% CI, 2.7 to 67.3). The recurrence rate was 4.4% patient-years in patients with thrombophilia and 1.6% patient-years in those without thrombophilia. The HR for recurrent UEDVT in patients with thrombophilia compared with those without was 2.7 (95% CI, 0.7 to 9.8).	4
73. Monreal M, Raventos A, Lerma R, et al. Pulmonary embolism in patients with upper extremity DVT associated to venous central lines--a prospective study. *Thromb Haemost.* 1994;72(4):548-550.	Observational-Tx	79 patients	To evaluate the prevalence of PE, and to identify clinical variables that would increase the likelihood of developing PE in an individual patient.	13 patients were considered to have PE. 66 patients were finally classified as having a normal lung scan, and 7 patients were excluded from the study (because of indeterminate lung scan 6; because of femoropopliteal thrombosis simultaneously present 1). 2 out of the 13 patients with PE subsequently died because of recurrent, massive embolism, despite adequate heparin therapy. PE was more commonly present in patients with polyvinyl chloride or polyethylene catheters (10/38, 26%) as compared to patients with either polyurethane or siliconized catheters (3/41, 7%; $P<0.05$, Chi-Square test; OR = 4.52, 95% CI, 1.01–23.07).	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
74. Munoz FJ, Mismetti P, Poggio R, et al. Clinical outcome of patients with upper-extremity deep vein thrombosis: results from the RIETE Registry. *Chest.* 2008;133(1):143-148.	Review/Other-Tx	512 patients	To analyze the demographic characteristics, treatment, and 3-month outcome of all patients with DVT in the arm.	Of the 11,564 DVT patients enrolled, 512 patients (4.4%) had arm DVT. They presented less often with clinically overt PE (9.0% vs 29%; OR, 0.24; 95% CI, 0.18 to 0.33) than those with lower-limb DVT, but their 3-month outcome was similar. Of the 512 patients with arm DVT, 196 patients (38%) had cancer and 228 patients (45%) had catheter-related DVT. During follow-up, those with cancer DVT had an increased incidence of major bleeding (4.1% vs 0.9%; OR, 4.4; 95% CI, 1.2 to 21), recurrent VTE (6.1% vs 2.8%; OR, 2.2; 95% CI, 0.91 to 5.6; *P*=0.04), and death (22% vs 3.5%; OR, 7.8; 95% CI, 4.0 to 16). 30 patients had the composite event of recurrent DVT, symptomatic PE, or major bleeding. They were significantly older, more often had cancer, and presented more frequently with symptomatic PE on hospital admission. On multivariate analysis, only cancer patients with arm DVT had an increased risk for the composite event (OR, 3.0; 95% CI, 1.4 to 6.4).	4
75. Spencer FA, Emery C, Lessard D, Goldberg RJ. Upper extremity deep vein thrombosis: a community-based perspective. *Am J Med.* 2007;120(8):678-684.	Review/Other-Dx	483 patients 69 with UEDVT	Review medical records to examine the magnitude, risk factors, management strategies, and outcomes in a population-based investigation of patients with upper, as compared with lower, extremity DVT diagnosed in 1999.	Patients with UEDVT represent a clinically important patient population in the community setting. Risk factors, occurrence of PE, and timing and location of VTE recurrence differ between patients with upper as compared with lower extremity DVT.	4

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
76. Bozzetti F, Scarpa D, Terno G, et al. Subclavian venous thrombosis due to indwelling catheters: a prospective study on 52 patients. *JPEN J Parenter Enteral Nutr.* 1983;7(6):560-562.	Experimental-Tx	52 patients	To report the results of a prospective investigation in patients with subclavian vein catheters.	There were 26 polyvinyl chloride and 26 rubber silicone catheters, which were correctly positioned in the superior vena cava-atrium. Average duration of the intravenous stay was 12.8 days. Asymptomatic thrombosis was venographically demonstrated in 46.1% of the polyvinyl chloride catheters and in 11.5% of the silicone ones (P=0.005). The average age of catheters with or without thrombosis was 10.8 and 13.8 days, respectively. Addition of heparin to the infusate (1 U/ml) did not reduce the thrombosis rate in polyvinyl chloride or in silicone catheters, but risk of thrombosis was significantly higher (P=0.03) in polyvinyl chloride catheters without heparin in comparison to the silicone ones. Osmolarity of the infusional fluid, manipulation during the cannulation, colonization of the catheter tip, and duration of the intravenous stay of the catheter apparently did not influence the rate of thrombosis.	2
77. Male C, Chait P, Andrew M, Hanna K, Julian J, Mitchell L. Central venous line-related thrombosis in children: association with central venous line location and insertion technique. *Blood.* 2003;101(11):4273-4278.	Experimental-Tx	85 patients	To assess whether CVL location and insertion technique are associated with the incidence of VTE in children.	Among 85 children, 29 (34%) had VTE; 28 VTEs appeared in the upper venous system, and 1 was sinovenous thrombosis. Left-sided CVL (OR, 2.5; 95% CI, 1.0–6.4; P=.048), subclavian CVL (OR, 3.1; 95% CI, 1.2–8.5; P=.025), and percutaneous CVL insertion (OR, 3.5; 95% CI, 1.3–9.2; P=.011) were associated with an increased incidence of VTE. Interaction occurred between CVL vein location and insertion technique. Subclavian vein CVL inserted percutaneously had an increased incidence (54%) of VTE compared with any other combination (P=.07).	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
78. Shingarev R, Barker-Finkel J, Allon M. Natural history of tunneled dialysis catheters placed for hemodialysis initiation. *J Vasc Interv Radiol.* 2013;24(9):1289-1294.	Observational-Tx	472 patients	To analyze factors affecting patency and complications of first tunneled dialysis catheters placed in a large cohort of incident hemodialysis recipients.	The median patency of all tunneled dialysis catheters was 202 days. Left-sided placement of tunneled dialysis catheters was the only variable associated with inferior tunneled dialysis catheter patency (HR, 1.98; 95% CI, 1.39–2.81; *P*<.0001). The 6-month tunneled dialysis catheter patency rate was 37% for left internal jugular vein catheters, vs 54% for right internal jugular vein catheters. The 1-year patency rate was 6% for left internal jugular vein catheters, vs 35% for right internal jugular vein catheters. Catheter patency was not associated with patient age, sex, race, hypertension, diabetes, coronary artery disease, peripheral vascular disease, cerebrovascular disease, or heart failure. The median time to the first episode of CRB was 163 days. None of the clinical variables was associated with tunneled dialysis catheter infection.	3
79. Bonizzoli M, Batacchi S, Cianchi G, et al. Peripherally inserted central venous catheters and central venous catheters related thrombosis in post-critical patients. *Intensive Care Med.* 2011;37(2):284-289.	Observational-Tx	239 patients	To determine the thrombosis rate in relation to PICC placement in patients discharged from the ICU.	Data of 239 patients were analyzed (125 of CVC group, 114 of PICC group). A total of 2,747 CVC-days and 4,024 PICC-days of observation were included. Patient characteristics were comparable between groups. Patients with PICC had a significantly higher incidence rate of DVT than patients with CVC (27.2 vs 9.6%, *P*=0.0012). The rate of DVT/1,000 catheter days was 4.4 for CVCs and 7.7 for PICCs. 80% of DVTs occurred within 2 weeks after insertion. Binary logistic analysis showed a two-fold increased risk for women and a three-fold increased risk when using the left basilic vein in the PICC group.	1
80. Sriskandarajah P, Webb K, Chisholm D, et al. Retrospective cohort analysis comparing the incidence of deep vein thromboses between peripherally-inserted and long-term skin tunneled venous catheters in hemato-oncology patients. *Thromb J.* 2015;13:21.	Observational-Tx	346 PICC and 237 long term skin tunneled venous catheters patients	To compare the cumulative incidence of thrombotic events between peripherally-inserted and long term skin tunneled venous catheters.	346 patients had a PICC inserted with cumulative incidence of symptomatic thrombosis of 5.8%, while 237 patients had a long term skin tunneled venous catheters inserted with a cumulative incidence of 1.7% (*P*=0.003). Post-thrombotic complication rates, particularly infection, were higher in the PICC group compared to the LTSTC group (*P*=0.597).	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
81. Hind D, Calvert N, McWilliams R, et al. Ultrasonic locating devices for central venous cannulation: meta-analysis. *BMJ.* 2003;327(7411):361.	Meta-analysis	1646 participants; 18 trials	To assess the evidence for the clinical effectiveness of US-guided central venous cannulation.	18 trials (1646 participants) were identified. Compared with the landmark method, real time 2D US guidance for cannulating the internal jugular vein in adults was associated with a significantly lower failure rate both overall (RR 0.14, 95% CI, 0.06 to 0.33) and on the first attempt (0.59, 0.39 to 0.88). Limited evidence favored 2D US guidance for subclavian vein and femoral vein procedures in adults (0.14, 0.04 to 0.57 and 0.29, 0.07 to 1.21, respectively). 3 studies in infants confirmed a higher success rate with 2D US for internal jugular procedures (0.15, 0.03 to 0.64). Doppler guided cannulation of the internal jugular vein in adults was more successful than the landmark method (0.39, 0.17 to 0.92), but the landmark method was more successful for subclavian vein procedures (1.48, 1.03 to 2.14). No significant difference was found between these techniques for cannulation of the internal jugular vein in infants. An indirect comparison of RRs suggested that 2D US would be more successful than Doppler guidance for subclavian vein procedures in adults (0.09, 0.02 to 0.38).	M
82. Randolph AG, Cook DJ, Gonzales CA, Pribble CG. Ultrasound guidance for placement of central venous catheters: a meta-analysis of the literature. *Crit Care Med.* 1996;24(12):2053-2058.	Meta-analysis	8 RCTs	To evaluate the effect of real-time US guidance using a regular or Doppler US technique for placement of CVCs.	US guidance significantly decreases internal jugular and subclavian catheter placement failure (RR 0.32; 95% CI, 0.18 to 0.55), decreases complications during catheter placement (RR 0.22; 95% CI, 0.10 to 0.45), and decreases the need for multiple catheter placement attempts (RR 0.60; 95% CI, 0.45 to 0.79) when compared with the standard landmark placement technique.	M
83. Infusion Nursing Standards of Practice. *J Infus Nurs.* 2006;29(1 Suppl):S1-92.	Review/Other-Tx	N/A	No abstract available.	No abstract available.	4
84. Bishop L, Dougherty L, Bodenham A, et al. Guidelines on the insertion and management of central venous access devices in adults. *Int J Lab Hematol.* 2007;29(4):261-278.	Review/Other-Tx	N/A	To review the types of access devices available and make a number of major recommendations.	No results stated in abstract.	4

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85. Calvert N, Hind D, McWilliams R, Davidson A, Beverley CA, Thomas SM. Ultrasound for central venous cannulation: economic evaluation of cost-effectiveness. *Anaesthesia.* 2004;59(11):1116-1120.	Review/Other-Tx	N/A	To compare the economics of using two-dimensional US locating devices and more traditional landmark methods for central venous cannulation in the National Health Service (NHS).	The marginal economic cost of using US for central venous cannulation was less than 10 pounds sterling per procedure, assuming that a machine is used for 15 procedures each week. The base case scenario implied that 2000 pounds sterling worth of resource savings result for every 1000 procedures undertaken and 90 avoided complications. Sensitivity analysis indicated that the results of modelling appear robust to the central assumptions used.	4
86. Pratt RJ, Pellowe CM, Wilson JA, et al. epic2: National evidence-based guidelines for preventing healthcare-associated infections in NHS hospitals in England. *J Hosp Infect.* 2007;65 Suppl 1:S1-64.	Review/Other-Tx	N/A	To provide comprehensive recommendations for preventing HCAI in hospitals and other acute care settings based on the best currently available evidence.	No result stated in abstract.	4
87. Vescia S, Baumgartner AK, Jacobs VR, et al. Management of venous port systems in oncology: a review of current evidence. *Ann Oncol.* 2008;19(1):9-15.	Review/Other-Tx	N/A	To review the current literature on long-term complications of venous port systems, focusing on infection and thrombosis as well as on their routine maintenance in follow-up care.	Sterile precautions are essential when implanting and accessing port systems. Infections must be treated with adequate antimicrobial therapy. Catheter-related thromboembolic complications were found at a rate of 12-64% in retrospective studies. Five current clinical trials investigated the effect of prophylactic anticoagulation with either low molecular weight heparin or warfarin in cancer patients with central venous devices. On the basis of these results, routine anticoagulation cannot be recommended.	4
88. Kuo YS, Schwartz B, Santiago J, Anderson PS, Fields AL, Goldberg GL. How often should a port-A-cath be flushed? *Cancer Invest.* 2005;23(7):582-585.	Observational-Tx	73 patients	To demonstrate that a longer interval between maintenance accessions of PACs still may be medically safe, convenient, and more efficient.	Compliance with visits for PAC maintenance varied considerably with the individual median accession times varying between 28 and 262 days with an overall median of 42 days. The individual means ranged from 29.5 to 244 days with an overall mean of 53.6 days. Seven patients in the group had episodes where the provider was unable to draw blood from the port during routine accession. The average intervals between accessions for each of these patients ranged from 38 to 244 days. The average intervals of accession among those patients who had no blood return during PAC accession was 79 days, vs 63 days for those without any difficulty. The difference was not statistically significant ($p>0.05$).	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
89. Hemmelgarn BR, Moist LM, Lok CE, et al. Prevention of dialysis catheter malfunction with recombinant tissue plasminogen activator. *N Engl J Med.* 2011;364(4):303-312.	Experimental-Tx	225 patients	To determine whether substituting rt-PA (1 mg in each lumen) for heparin once a week as a catheter locking solution, as compared with using heparin three times a week, would decrease the incidence of catheter malfunction and bacteremia.	A catheter malfunction occurred in 40 of the 115 patients assigned to heparin only (34.8%) and 22 of the 110 patients assigned to rt-PA (20.0%)--an increase in the risk of catheter malfunction by a factor of almost 2 among patients treated with heparin only as compared with those treated with rt-PA once weekly (HR, 1.91; 95% CI [CI], 1.13 to 3.22; *P*=0.02). Catheter-related bacteremia occurred in 15 patients (13.0%) assigned to heparin only, as compared with 5 (4.5%) assigned to rt-PA (corresponding to 1.37 and 0.40 episodes per 1000 patient-days in the heparin and rt-PA groups, respectively; *P*=0.02). The risk of bacteremia from any cause was higher in the heparin group than in the rt-PA group by a factor of 3 (HR, 3.30; 95% CI, 1.18 to 9.22; *P*=0.02). The risk of adverse events, including bleeding, was similar in the two groups.	1
90. Ragni MV, Journeycake JM, Brambilla DJ. Tissue plasminogen activator to prevent central venous access device infections: a systematic review of central venous access catheter thrombosis, infection and thromboprophylaxis. *Haemophilia.* 2008;14(1):30-38.	Review/Other-Tx	16 studies	To evaluate the role of t-PA in the prevention of CVAD-related infections in children with haemophilia.	Metanalysis of published thromboprophylaxis trials demonstrate current prophylaxis regimens do not prevent CVAD infection, and further, that thrombosis and infection do not necessarily occur simultaneously. Pilot data demonstrate CVAD infection reduction in hemophilic children by monthly t-PA in 18 hemophilic children, suggesting the potential role of t-PA in CVAD infection prevention.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
91. Moore CL, Besarab A, Ajluni M, et al. Comparative effectiveness of two catheter locking solutions to reduce catheter-related bloodstream infection in hemodialysis patients. *Clin J Am Soc Nephrol.* 2014;9(7):1232-1239.	Observational-Tx	555 patients	To evaluate the impact of a prophylactic antibiotic lock solution on the incidence of CRBSI and mortality.	The study population (n=555 and 1350 catheters) had a median age of 62 years (interquartile range=41-83 years), with 50% men and 71% black. There were 427 patients evaluable in the heparin period (84,326 days) and 322 patients evaluable in the antibiotic lock period (71,192 days). CRBSI in the antibiotic lock period (0.45/1000 catheter days) was 73% lower than the heparin period (1.68/1000 catheter days; *P*=0.001). Antibiotic lock use was associated with a decreased risk of CRBSI compared with heparin (risk ratio, 0.23; 95% CI, 0.13 to 0.38 after multivariate adjustment). Cox proportional hazards modeling found that antibiotic lock was associated with a reduction in mortality (HR, 0.36; 95% CI, 0.22 to 0.58 in unadjusted analyses; HR, 0.32; 95% CI, 0.14 to 0.75 after multivariate adjustment). The rate of gentamicin-resistant organisms decreased (0.40/1000 person-years to 0.22/1000 person-years) in the antibiotic lock period (*P*=0.01).	1

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
92. Zhao Y, Li Z, Zhang L, et al. Citrate versus heparin lock for hemodialysis catheters: a systematic review and meta-analysis of randomized controlled trials. *Am J Kidney Dis.* 2014;63(3):479-490.	Meta-analysis	13 RCTs; 1,770 patients and 221,064 catheter days	To assess whether citrate locks are superior to heparin locks in the maintenance of catheter patency and the prevention of CRIs in patients receiving hemodialysis.	Primary outcomes include CRBSI, exit-site infection, catheter removal for poor flow, and thrombolytic treatment. 13 RCTs (1,770 patients, 221,064 catheter-days) met the inclusion criteria. Pooled analyses found that citrate locks could significantly reduce the incidence of CRBSI (RR, 0.39; 95% CI, 0.27–0.56; $P<0.001$). Subgroup analysis showed that antimicrobial-containing citrate locks (citrate + gentamicin, citrate + taurolidine, and citrate + methylene blue + methylparaben + propylparaben) were superior to heparin locks in the prevention of CRBSI ($P<0.001$, $P=0.003$, and $P=0.008$, respectively), whereas citrate alone failed to show a similar advantage ($P=0.2$). Low- (1.04%–4%) to moderate-concentration (4.6%–7%) citrate locks were associated with decreased CRBSI incidence ($P<0.001$ and $P=0.003$, respectively), but patients receiving high-concentration (30%–46.7%) citrate and heparin locks had similar incidences ($P=0.3$). The incidence of bleeding episodes (RR, 0.48; 95% CI, 0.30–0.76; $P=0.002$) was significantly lower in patients receiving citrate locks, whereas both groups were similar in terms of exit-site infection ($P=0.2$), catheter removal for poor flow ($P=0.9$), thrombolytic treatment ($P=0.8$), all-cause death ($P=0.3$), catheter thrombosis ($P=0.9$), mean catheter duration ($P=0.2$), CRBSI-free catheter survival ($P=0.2$), and catheter-related readmission ($P=0.5$).	M

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
93. Carrier M, Tay J, Fergusson D, Wells PS. Thromboprophylaxis for catheter-related thrombosis in patients with cancer: a systematic review of the randomized, controlled trials. *J Thromb Haemost.* 2007;5(12):2552-2554.	Meta-analysis	7 studies; 2,131 patients	To expand and update the literature by incorporating data from two further multi-center, randomized trials.	The pooled RR of symptomatic catheter-related thrombosis from the seven RCTs that assessed thromboprophylaxis was 0.71 (95% CI 0.42–1.20; Fig. 1). The pooled estimates of thromboprophylaxis with LMWH and warfarin were 0.43 (95% CI 0.12–1.56) and 0.82 (95% CI 0.46–1.47), respectively. Six out of seven studies reported on overall mortality. No statistically significant mortality benefit was found with either LMWH (RR 1.51; 95% CI 0.49–4.70) or warfarin (RR 0.95; 95% CI 0.62–1.46). Two studies reported on major bleeding, with Karthaus et al. [11] reporting a RR of 0.49 (95% CI 0.03– 7.83) and Couban et al. [9] reporting a RR of 0.14 (95% CI 0.001–2.63). Minor bleeding was not more frequent in patients given thromboprophylaxis with either LMWH (pooled RR 1.32; 95% CI 0.87–2.02) or low-dose warfarin (pooled RR 0.93; 95% CI 0.31–2.77). Heterogeneity for all analyses was nonsignificant or low to moderate, as demonstrated by the chi-square and I 2 tests.	M
94. Kirkpatrick A, Rathbun S, Whitsett T, Raskob G. Prevention of central venous catheter-associated thrombosis: a meta-analysis. *Am J Med.* 2007;120(10):901 e901-913.	Meta-analysis	15 studies	To clarify the efficacy and safety of anticoagulant administration for prevention of catheter-associated VTE.	Unfractionated heparin infusion, oral fixed low-dose vitamin K antagonist, and subcutaneous low-molecular-weight heparin were evaluated. For all catheter-associated DVT (symptomatic and asymptomatic combined), the summary RRs ranged from 0.31 to 0.73 (all achieved statistical significance). For symptomatic DVT, the summary RRs ranged from 0.28 to 0.72, but did not achieve statistical significance for any individual regimen.	M

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
95. van Rooden CJ, Schippers EF, Guiot HF, et al. Prevention of coagulase-negative staphylococcal central venous catheter-related infection using urokinase rinses: a randomized double-blind controlled trial in patients with hematologic malignancies. *J Clin Oncol.* 2008;26(3):428-433.	Experimental-Tx	160 patients	To investigate whether three times weekly urokinase rinsing of CVC reduces the incidence or severity of CVC-related infections by CoNS in patients undergoing intensive cytotoxic treatment for hematologic malignancies.	The percentage of patients with at least one positive culture with CoNS was lower in patients receiving urokinase compared with patients receiving placebo (26% v 42%, respectively; RR = 0.61; 95% CI, 0.39 to 0.94). Major CVC-related CoNS infection occurred less frequently in patients receiving urokinase vs placebo (1.2% v 14.1%, respectively; RR = 0.09; 95% CI, 0.01 to 0.50). Secondary complications, including CVC-related thrombosis, were observed less frequently in the urokinase group compared with the placebo group (1.3% v 9.0%, respectively; RR = 0.14; 95% CI, 0.02 to 0.82). No severe bleeding complications attributable to urokinase were observed.	1
96. Young AM, Billingham LJ, Begum G, et al. Warfarin thromboprophylaxis in cancer patients with central venous catheters (WARP): an open-label randomised trial. *Lancet.* 2009;373(9663):567-574.	Experimental-Tx	1,590 patients	To assess whether warfarin reduces catheter-related thrombosis compared with no warfarin and whether the dose of warfarin determines the thromboprophylactic effect.	Compared with no warfarin (n=404), warfarin (n=408; 324 [79%] on fixed-dose and 84 [21%] on dose-adjusted) did not reduce the rate of catheter-related thromboses (24 [6%] vs 24 [6%]; RR 0.99, 95% CI 0.57-1.72, *P*=0.98). However, compared with fixed-dose warfarin (n=471), dose-adjusted warfarin (n=473) was superior in the prevention of catheter-related thromboses (13 [3%] vs 34 [7%]; 0.38, 0.20-0.71, *P*=0.002). Major bleeding events were rare; an excess was noted with warfarin compared with no warfarin (7 vs 1, *P*=0.07) and with dose-adjusted warfarin compared with fixed-dose warfarin (16 vs 7, *P*=0.09). A combined endpoint of thromboses and major bleeding showed no difference between comparisons. We did not note a survival benefit in either comparison.	1
97. Kearon C, Kahn SR, Agnelli G, Goldhaber S, Raskob GE, Comerota AJ. Antithrombotic therapy for venous thromboembolic disease: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th Edition). *Chest.* 2008;133(6 Suppl):454S-545S.	Review/Other-Tx	N/A	To provide recommendations on treatment for venous thromboembolic disease as part of the American College of Chest Physicians Evidence-Based Clinical Practice Guidelines (8th Edition).	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
98. Ponec D, Irwin D, Haire WD, Hill PA, Li X, McCluskey ER. Recombinant tissue plasminogen activator (alteplase) for restoration of flow in occluded central venous access devices: a double-blind placebo-controlled trial--the Cardiovascular Thrombolytic to Open Occluded Lines (COOL) efficacy trial. *J Vasc Interv Radiol.* 2001;12(8):951-955.	Experimental-Tx	149 patients	To determine the efficacy of alteplase in occluded catheters without earlier contrast injections or radiographic examinations.	After the first 2-hour treatment, function was restored to 74% in the alteplase arm and 17% in the placebo arm (P<.0001 compared to placebo). After one or two treatments, function was restored in 90% of patients. There were no serious study-drug-related adverse events, no intracranial hemorrhage, no major hemorrhage, and no embolic events.	1
99. Semba CP, Deitcher SR, Li X, Resnansky L, Tu T, McCluskey ER. Treatment of occluded central venous catheters with alteplase: results in 1,064 patients. *J Vasc Interv Radiol.* 2002;13(12):1199-1205.	Experimental-Tx	1,064 patients	To analyze the safety and efficacy of alteplase after administration of a maximum of two 2-mg/2-mL doses to thrombosed CVADs.	A total of 1,064 patients (465 men, 599 women; mean age, 50.7 y; range, 2-91 y) with dysfunctional catheters were treated. After alteplase administration, function was restored in 798 patients (75.0%; 95% CI: 72.3%, 77.6%) after one dose and 905 (85.1%; 95% CI: 82.8%, 87.2%) after two doses. Efficacy rates were similar among catheter types (single-, double-, and triple-lumen catheters, and ports). Serious adverse events monitored within 30 days of treatment included ICH (0.0%), embolic events (0.0%), gastrointestinal bleeding (0.3%), thrombosis (0.3%), and sepsis (0.4%). One event (fever) was attributed to the study drug. Efficacy was independent of age, sex, body weight, and catheter type.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
100. Oguzkurt L, Tercan F, Torun D, Yildirim T, Zumrutdal A, Kizilkilic O. Impact of short-term hemodialysis catheters on the central veins: a catheter venographic study. *Eur J Radiol.* 2004;52(3):293-299.	Observational-Tx	57 patients	To determine the incidence of pericatheter sleeve formation, thrombus formation, and stenosis of the central veins in hemodialysis patients with temporary catheters.	The catheter location was right internal jugular vein (IJV) in 26 cases, right subclavian vein (SCV) in 27 cases, left IJV in 1 case, and left SCV in 3 cases. Thirty-two patients (56%) had had only one temporary catheter and the rest had had more than one inserted. The mean dwell time for the catheters was 21 days (range 7-59 days). A pericatheter sleeve was detected on venography in 32 (56%) patients and thrombus formation was noted in 16 patients (28%). A total of 41 patients (72%) exhibited pericatheter sleeve and/or thrombus formation. While 19 of the 32 patients (59%) without previous catheterization had a sleeve around the catheter, only 13 (52%) of 25 patients who had had multiple catheters inserted had a sleeve ($P > 0.005$). Of the eight patients (14%) with BCV stenosis, two had >50% stenosis. Only one patient (2%) had mild stenosis of the SVC. Three patients out of 15 (20%) who had diagnostic venography for the IJV had severe stenosis of the vein. Pericatheter sleeve formation was more frequent in women ($P<0.005$). However, there were no statistical differences with respect to pericatheter sleeve formation, luminal filling defect and BCV stenosis when patients were grouped according to age, dwell time of the catheter, number of catheters inserted, and diameter of the SVC. Forty-two of the fifty-seven patients had had only right IJV (n =16) or right SCV (n = 26) catheters. There were no differences between these groups with respect to rates of pericatheter sleeve formation, thrombus formation, or BCV stenosis.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
101. Janne d'Othee B, Tham JC, Sheiman RG. Restoration of patency in failing tunneled hemodialysis catheters: a comparison of catheter exchange, exchange and balloon disruption of the fibrin sheath, and femoral stripping. *J Vasc Interv Radiol.* 2006;17(6):1011-1015.	Observational-Tx	66 procedures in 45 patients	To compare median patency times after treatment of malfunctioning tunneled hemodialysis catheters by one of three techniques: over-the-wire catheter exchange (CE), fibrin sheath stripping (FSS) from a femoral vein approach, and over-the-wire catheter removal with balloon dilation of fibrin sheath (DFS) followed by catheter replacement with use of the same tract.	No significant differences in baseline parameters were identified among the three groups (P>.05). Mean follow-up duration (67+/-89 days; range, 0-398 d) was similar among the three groups. The immediate technical success rate was 100%, and there were no complications. Cumulative catheter patency rates were 73% (CE), 72% (FSS), and 65% (DFS) at 1 month; 43% (CE), 60% (FSS), and 39% (DFS) at 3 months; and 28% (CE), 45% (FSS), and 39% (DFS) at 6 months. Median duration of patency was similar among groups (*P*=.60).	2

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
102. Debourdeau P, Farge D, Beckers M, et al. International clinical practice guidelines for the treatment and prophylaxis of thrombosis associated with central venous catheters in patients with cancer. *J Thromb Haemost.* 2013;11(1):71-80.	Review/Other-Tx	N/A	To establish common international Good Clinical Practices Guidelines (GCPG) for the management of CRT in cancer patients.	For the treatment of established CRT in cancer patients, we found no prospective randomized studies, two non-randomized prospective studies and one retrospective study examining the efficacy and safety of low-molecular-weight heparin (LMWH) plus vitamin K antagonists (VKAs). One retrospective study evaluated the benefit of CVC removal and two small retrospective studies were on thrombolytic drugs. For the treatment of symptomatic CRT, anticoagulant treatment (AC) is recommended for a minimum of 3 months; in this setting, LMWHs are suggested. VKAs can also be used, in the absence of direct comparisons of these two types of anticoagulants in this setting [Guidance]. The CVC can be kept in place if it is functional, well-positioned and non-infected and there is good resolution under close surveillance; whether the CVC is kept or removed, no standard approach in terms of AC duration has been established [Guidance]. For the prophylaxis of CRT in cancer patients, we found six randomized studies investigating the efficacy and safety of VKA vs placebo or no treatment, one on the efficacy and safety of unfractionnated heparin, six on the value of LMWH, one double-blind randomized and one non randomized study on thrombolytic drugs and six meta-analyses of AC and CVC thromboprophylaxis. Type of catheter (open-ended like the Hickman((R)) catheter vs closed-ended catheter with a valve like the Groshong((R)) catheter), its position (above, below or at the junction of the superior vena cava and the right atrium) and method of placement may influence the onset of CRT on the basis of six retrospective trials, four prospective non-randomized trials, three randomized trials and one meta-analysis. In light of these data: use of AC for routine prophylaxis of CRT is not recommended [1A]; a CVC should be inserted on the right side, in the jugular vein, and distal extremity of the CVC should be located at the junction of the superior vena cava and the right atrium [1A].	4

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
103. Sabeti S, Schillinger M, Mlekusch W, Haumer M, Ahmadi R, Minar E. Treatment of subclavian-axillary vein thrombosis: long-term outcome of anticoagulation versus systemic thrombolysis. *Thromb Res.* 2002;108(5-6):279-285.	Observational-Tx	95 patients	To investigate long-term clinical and morphological outcome of patients with subclavian-axillary vein thrombosis treated with systemic thrombolysis compared to anticoagulation in a retrospective, nonrandomized study.	Primary technical success rate of the systemic thrombolysis was 88% (n=29) with seven peri-intervention bleeding complications (21%). No complication was observed in patients with anticoagulation only (P<0.0001). At the time of follow-up, duplex sonography showed a thrombotic subclavian vein in 40 of 83 patients (48%), but only 9 of 95 patients (10%) had a symptomatic upper extremity post-thrombotic syndrome. Patients with systemic thrombolysis exhibited a 60% adjusted reduced risk for a thrombotic subclavian vein at the time of follow-up compared to patients with anticoagulation only (95% CI: 0.2 to 0.9, P=0.03). However, the frequency of symptomatic post-thrombotic syndrome after thrombolysis and anticoagulation was similar (adjusted P=0.6).	2
104. Vik A, Holme PA, Singh K, et al. Catheter-directed thrombolysis for treatment of deep venous thrombosis in the upper extremities. *Cardiovasc Intervent Radiol.* 2009;32(5):980-987.	Observational-Tx	30 patients	To report thrombolytic efficacy, complications, and follow-up data on post-thrombotic syndrome and reocclusion for patients treated with CDT for UEDVT at the University Hospital of North Norway and Rikshospitalet University Hospital, Oslo, between 2002 and 2007.	UEDVT was unprovoked in 11 (37%) cases and effort related in 9 (30%) cases. The median duration of symptoms prior to CDT was 7.0 days (range, 1-30); median duration of thrombolysis treatment, 70 h (range, 24-264 h); and the median amount of rt-PA infused during CDT, 52 mg (range, 19-225 mg). Major bleeding was registered in three (9%) patients, and CDT was stopped prematurely in three patients due to local hematoma. No intracerebral bleeding, clinical PE, or deaths occurred during treatment. Grade II (>50%) or III (>90%) lysis was present in 29 patients (97%) at the end of CDT. Bleeding complications increased by each day of delay from the debut of symptoms to the start of treatment (OR, 1.20; 95% CI, 1.01-1.42). At follow-up (n = 29; median, 21 months; range, 5-58 months), 11 (38%) patients had occluded veins, whereas 18 (62%) had patent veins. However, stenosis of varying severity was present in eight of those with a patent vein. No patients had severe post-thrombotic syndrome, whereas six (21%) experienced mild post-thrombotic syndrome.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
105. Nayeemuddin M, Pherwani AD, Asquith JR. Imaging and management of complications of central venous catheters. *Clin Radiol.* 2013;68(5):529-544.	Review/Other-Tx	N/A	To demonstrate the imaging of a range of complications associated with CVCs and discusses their management with catheter salvage techniques.	No results stated in abstract.	4
106. Owens CA, Bui JT, Knuttinen MG, Gaba RC, Carrillo TC. Pulmonary embolism from upper extremity deep vein thrombosis and the role of superior vena cava filters: a review of the literature. *J Vasc Interv Radiol.* 2010;21(6):779-787.	Review/Other-Tx	N/A	To find any associated risks with SVC filters in addition to the incidence of and the mortality associated with PE arising from UEDVT.	A total of 21 publications were identified that reported 209 SVC filters and documented eight major filter-related complications (3.8%), including four cardiac tamponades, two aortic perforations, and one recurrent pneumothorax. The in-hospital or 1-month mortality rate was 43.1%. Twenty-eight additional publications were identified that reported 3,747 cases of UEDVT. The rates of PE and associated mortality were 5.6% and 0.7%, respectively. Studies imaging both upper and lower extremities found deep vein thrombus 14.7 times more likely to occur in the lower extremities and the rate of PE from a lower-extremity thrombus to be 25.1%.	4
107. Mir MA. Superior vena cava filters: hindsight, insight and foresight. *J Thromb Thrombolysis.* 2008;26(3):257-261.	Review/Other-Tx	N/A	To present the unique indications, contraindications, complications and technical challenges of SVC filter insertion as from their IVC counterparts.	No results stated in abstract.	4
108. Usoh F, Hingorani A, Ascher E, et al. Long-term follow-up for superior vena cava filter placement. *Ann Vasc Surg.* 2009;23(3):350-354.	Review/Other-Tx	154 patients	To review our experience with 154 patients who received SVC filter for UEDVT.	There were 69 males and 85 females with a mean age of 73.6 years (range, 16-96 years; +/-15.3 [SD] years). Follow-up ranged from 1 day to 3750 days (256.3 +/- 576 days [mean +/- SD]) and 5 patients were lost to follow-up. Of the 154 patients, 58 survived longer than 60 days with mean follow-up of 628.4 days. All SVC filters (TrapEase, n = 38; Greenfield, n = 116) were successfully deployed in the 154 patients. During the follow-up, 114 (74.0% mortality) of the patients died of chronic illness or from cancer complications. There were three cases of pericardial tamponade (1.9%), and one case of misplaced filter in innominate vein. There were no known cases of symptomatic PE, caval occlusion, pneumothorax, or filter migration. SVC filter placement is associated with a low incidence of complications with long-term follow-up.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
109. Bouza E, San Juan R, Munoz P, Pascau J, Voss A, Desco M. A European perspective on intravascular catheter-related infections: report on the microbiology workload, aetiology and antimicrobial susceptibility (ESGNI-005 Study). *Clin Microbiol Infect.* 2004;10(9):838-842.	Review/Other-Tx	151 hospitals	To obtain general information on the microbiology workload and techniques used for IV-CRI diagnosis in Europe, as well as the etiology and antimicrobial susceptibility patterns of pathogens causing intravenous catheter colonization.	Overall, EU centers received significantly more catheter tip samples/1,000 admissions and had a significantly higher rate of 'positivity' (P<0.0001) than non-EU centers. Of the institutions surveyed, 11.4% (7.2% in EU countries and 23.7% in non-EU countries; p 0.04) used only qualitative techniques for catheter tip sample processing. On the day of the study, 167 microorganisms were recovered from significant catheter tip cultures (122 patients), of which Gram-positive bacteria represented 70.7%, Gram-negative bacteria 22.2%, and yeasts 7.2%. The five most common microorganisms were coagulase-negative staphylococci, Staphylococcus aureus, Candida spp., Enterococcus spp. and Pseudomonas spp. Overall, 19% of catheter tip cultures were polymicrobial. In the case of S. aureus, 40% of isolates were resistant to oxacillin, as were 63.4% of coagulase-negative staphylococcus isolates. Of 37 Gram-negative isolates, 35% were resistant to cefotaxime, 31% to ceftazidime, and 27% to ciprofloxacin. Imipenem and cefepime had the lowest reported rates of resistance (11%).	4
110. Mermel LA, Allon M, Bouza E, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. *Clin Infect Dis.* 2009;49(1):1-45.	Review/Other-Tx	N/A	No abstract available.	No abstract available.	4
111. O'Grady NP, Alexander M, Dellinger EP, et al. Guidelines for the prevention of intravascular catheter-related infections. Centers for Disease Control and Prevention. *MMWR Recomm Rep.* 2002;51(RR-10):1-29.	Review/Other-Tx	N/A	To provide evidence-based recommendations for preventing CRI.	No results stated in abstract.	4
112. Bouza E, Burillo A, Munoz P. Catheter-related infections: diagnosis and intravascular treatment. *Clin Microbiol Infect.* 2002;8(5):265-274.	Review/Other-Tx	N/A	To review the diagnosis and intravascular treatment of CRI.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
113. Marschall J, Mermel LA, Classen D, et al. Strategies to prevent central line-associated bloodstream infections in acute care hospitals. *Infect Control Hosp Epidemiol.* 2008;29 Suppl 1:S22-30.	Review/Other-Tx	N/A	To highlight practical recommendations in a concise format designed to assist acute care hospitals in implementing and prioritizing their CLABSI prevention efforts.	No results stated in abstract.	4
114. van der Kooi TI, Wille JC, van Benthem BH. Catheter application, insertion vein and length of ICU stay prior to insertion affect the risk of catheter-related bloodstream infection. *J Hosp Infect.* 2012;80(3):238-244.	Observational-Tx	3,750 CVCs	To evaluate risk factors for CRBSI.	Of the CVCs surveyed, 1.6% [95% CI (CI) 1.2-2.0] resulted in CRBSI, representing 2.0/1000 CVC-days (95% CI 1.6-2.6). Multivariate analysis revealed that the length of ICU stay prior to CVC insertion, insertion in the jugular or femoral vein, and use of the CVC to deliver total parenteral nutrition increased the risk of CRBSI, whereas use of the CVC to deliver antibiotics decreased the risk of CRBSI.	2
115. Sandoe JA, Kumar B, Stoddart B, et al. Effect of extended perioperative antibiotic prophylaxis on intravascular catheter colonization and infection in cardiothoracic surgery patients. *J Antimicrob Chemother.* 2003;52(5):877-879.	Observational-Tx	179 patients	To investigate the effect of extended routine perioperative antibiotic prophylaxis in cardiothoracic patients on rates of intravascular catheter (IVC) colonization and infection.	Twenty-three out of 146 (16%) IVCs in the 'routine' group and four out of 33 (12%) in the 'extended' group became colonized; no IVC-related bloodstream infections occurred during the survey. The duration of IVC placement and the types of operation performed in the two groups were not significantly different ($P > 0.05$).	2
116. Yoshida J, Ishimaru T, Kikuchi T, Matsubara N, Asano I. Association between risk of bloodstream infection and duration of use of totally implantable access ports and central lines: a 24-month study. *Am J Infect Control.* 2011;39(7):e39-43.	Observational-Tx	977 patients	To evaluate over a 24-month period the association between risk of BSI and duration of AP use in comparison with the use of a CVL (CL).	BSIs occurred in 81 patients with an AP, for a BSI rate of 2.81 cases per 1,000 days of use. Among the 896 patients with a CL, the BSI rate was 5.60 cases per 1,000 days of use. The ROC analysis found a cutoff time of 33 days for APs (median days of use, 48) and 10 days for CLs (median days of use, 20.5). For the total 22,481 days of use, the OR between APs and CLs with respect to BSI was 0.556 (95% CI [CI], 0.256-1.208; P=.138). Days of use beyond the cutoff had an OR of 2.867 (95% CI, 1.823-4.507; P<.001). Among the risk factors, preexisting sepsis had an OR of 7.843 (95% CI, 4.666-13.184; P<.001).	3

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
117. Gunst M, Matsushima K, Vanek S, Gunst R, Shafi S, Frankel H. Peripherally inserted central catheters may lower the incidence of catheter-related blood stream infections in patients in surgical intensive care units. *Surg Infect (Larchmt).* 2011;12(4):279-282.	Observational-Tx	121 patients	To compare the rate of CVC and PICC-related infections in long-stay (14 days) SICU patients.	There were 13 CVC infections and one PICC infection, resulting in an infection rate of 6.0/1,000 catheter-days for CVCs and 2.2/1,000 for PICCs. Infected and non-infected CVCs were in place a mean of 25 +/- 11 and 16 +/- 9 days, respectively. The infected PICC was in place for 19 days, whereas the remainder of the PICCs were in place a mean of 14 +/- 17 days. Logistic regression demonstrated that line days (duration of catheterization) was the only independent predictor of CVC infection (P=0.015).	2
118. Bleasdale SC, Trick WE, Gonzalez IM, Lyles RD, Hayden MK, Weinstein RA. Effectiveness of chlorhexidine bathing to reduce catheter-associated bloodstream infections in medical intensive care unit patients. *Arch Intern Med.* 2007;167(19):2073-2079.	Experimental-Tx	836 patients	To determine whether patients bathed daily with chlorhexidine gluconate have a lower incidence of primary bloodstream infections compared with patients bathed with soap and water.	Patients in the chlorhexidine gluconate intervention arm were significantly less likely to acquire a primary bloodstream infections (4.1 vs 10.4 infections per 1000 patient days; incidence difference, 6.3 [95% CI, 1.2-11.0). The incidences of other infections, including clinical sepsis, were similar between the units. Protection against primary bloodstream infections by chlorhexidine gluconate cleansing was apparent after 5 or more days in the medical ICU.	2
119. Vernon MO, Hayden MK, Trick WE, Hayes RA, Blom DW, Weinstein RA. Chlorhexidine gluconate to cleanse patients in a medical intensive care unit: the effectiveness of source control to reduce the bioburden of vancomycin-resistant enterococci. *Arch Intern Med.* 2006;166(3):306-312.	Experimental-Tx	1787 patients	To evaluate the effect of source control on patients' skin colonization by vancomycin-resistant enterococci, measured the effect on vancomycin-resistant enterococci contamination of environmental surfaces and health care workers' hands, and assessed all patients for vancomycin-resistant enterococci acquisition.	Compared with soap and water baths, cleansing patients with chlorhexidine-saturated cloths resulted in 2.5 log(10) less colonies of vancomycin-resistant enterococci on patients' skin and less vancomycin-resistant enterococci contamination of health care workers' hands (RR, 0.6; 95% CI, 0.4-0.8) and environmental surfaces (RR, 0.3; 95% CI, 0.2-0.5). The incidence of vancomycin-resistant enterococci acquisition decreased from 26 colonizations per 1000 patient-days to 9 per 1000 patient-days (RR, 0.4; 95% CI, 0.1-0.9). For all measures, effectiveness of cleansing with nonmedicated cloths was similar to that of soap and water baths.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
120. Yamamoto AJ, Solomon JA, Soulen MC, et al. Sutureless securement device reduces complications of peripherally inserted central venous catheters. *J Vasc Interv Radiol.* 2002;13(1):77-81.	Experimental-Tx	170 patients	To evaluate the performance of a sutureless adhesive-backed device, StatLock, for securement of PICCs. To determine whether a sutureless securement device offers an advantage over suture in preventing catheter-related complications.	The groups had equivalent demographic characteristics and catheter indications. Average securement time with StatLock was significantly shorter (4.7 minutes vs 2.7 minutes; *P*<.001). Although StatLock was associated with fewer total complications (42 vs 61), this difference did not achieve significance. However, there were significantly fewer PICC-related bloodstream infections in the StatLock group (2 vs 10; *P*=.032). One securement-related needle-stick injury was documented during suturing of a PICC.	1
121. Casey AL, Burnell S, Whinn H, Worthington T, Faroqui MH, Elliott TS. A prospective clinical trial to evaluate the microbial barrier of a needleless connector. *J Hosp Infect.* 2007;65(3):212-218.	Experimental-Tx	50 patients	To compare the microbial contamination rate associated with three-way stopcock luers with standard caps to those with Y-type extension set luers with Clearlink needleless connectors attached.	The microbial contamination of 393 luers, 200 with standard caps and 193 with Clearlink attached, was determined. The internal surfaces of 20 of 200 (10%) three-way stopcock luers with standard caps were contaminated with micro-organisms whereas only one of 193 (0.5%) luers with Clearlink attached was contaminated (*P*<0.0001).	1
122. Casey AL, Worthington T, Lambert PA, Quinn D, Faroqui MH, Elliott TS. A randomized, prospective clinical trial to assess the potential infection risk associated with the PosiFlow needleless connector. *J Hosp Infect.* 2003;54(4):288-293.	Experimental-Tx	77 patients	To assess the potential infection risk associated with the PosiFlow needleless connector.	The internal surfaces of 55 out of 306 (18%) luers with standard caps were contaminated with micro-organisms, whilst only 18 out of 274 (6.6%) luers with needleless connectors were contaminated (*P*<0.0001). Of those needleless connectors disinfected with isopropyl alcohol, 69.2% were externally contaminated with micro-organisms compared with 30.8% disinfected with chlorhexidine/alcohol (*P*<0.0001) and 41.6% with povidone-iodine (*P*<0.0001).	1
123. Yebenes JC, Vidaur L, Serra-Prat M, et al. Prevention of catheter-related bloodstream infection in critically ill patients using a disinfectable, needle-free connector: a randomized controlled trial. *Am J Infect Control.* 2004;32(5):291-295.	Experimental-Tx	243 patients; 278 catheters	To assess the efficacy of a disinfectable, needle-free connector in the prophylaxis of CRBSI.	The study included 243 patients, with a total of 278 central venous catheters. The catheters' mean insertion duration was 9.9 days. Both groups were comparable regarding patient and catheter characteristics. Incidence rate of CRBSI was 0.7 per 1000 days of catheter use in the study group, compared with 5.0 per 1000 days of catheter use in the control group (*P*=.03).	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
124. Soothill JS, Bravery K, Ho A, Macqueen S, Collins J, Lock P. A fall in bloodstream infections followed a change to 2% chlorhexidine in 70% isopropanol for catheter connection antisepsis: a pediatric single center before/after study on a hemopoietic stem cell transplant ward. *Am J Infect Control.* 2009;37(8):626-630.	Observational-Tx	112 patients	To investigate whether catheter connector antisepsis with 2% chlorhexidine in 70% isopropanol prevents more CRBSI than does antisepsis with 70% isopropanol alone.	The infection rate before the change was 12 per 1000 catheter-days, and, following the change, this fell to 3 per 1000 catheter-days (*P*=.004). Similar falls followed the introduction of chlorhexidine to other wards.	2
125. Kamboj M, Blair R, Bell N, et al. Use of Disinfection Cap to Reduce Central-Line-Associated Bloodstream Infection and Blood Culture Contamination Among Hematology-Oncology Patients. *Infect Control Hosp Epidemiol.* 2015;36(12):1401-1408.	Observational-Tx	Not stated.	To examine the impact of routine use of a passive disinfection cap for catheter hub decontamination in hematology-oncology patients.	Implementation of a passive disinfection cap resulted in a 34% decrease in hospital-wide HA-CLABSI rates (combined P1 and P2 baseline rate of 2.66-1.75 per 1,000 catheter days at the end of the study period). This reduction occurred only among high-risk patients and not among general oncology patients. In addition, the use of the passive disinfection cap resulted in decreases of 63% (HRUs) and 51% (general oncology units) in blood culture contamination, with an estimated reduction of 242 BCCs with CONS. The reductions in HA-CLABSI and BCC correspond to an estimated annual savings of $3.2 million in direct medical costs.	2
126. Merrill KC, Sumner S, Linford L, Taylor C, Macintosh C. Impact of universal disinfectant cap implementation on central line-associated bloodstream infections. *Am J Infect Control.* 2014;42(12):1274-1277.	Observational-Tx	Not stated.	To analyze the effect of universal IV needleless connector disinfectant cap implementation on the rate and type of CLABSI and estimated costs in a large tertiary care center using a standard central line bundle.	The rate of CLABSI decreased following implementation of the disinfectant cap. The incidence rate ratios (.577, *P*=.004) for implementing the disinfectant caps was statistically significant, indicating that the rate of patient infections decreased by >40%. Increased compliance rates were associated with lower infection rates. Disinfectant cap use was associated with an estimated savings of almost $300,000 per year in the hospital studied.	2
127. Miller DL, O'Grady NP. Guidelines for the prevention of intravascular catheter-related infections: recommendations relevant to interventional radiology for venous catheter placement and maintenance. *J Vasc Interv Radiol.* 2012;23(8):997-1007.	Review/Other-Tx	N/A	To provide selected recommendations from the 2011CDC guideline, presented verbatim, along with selected supporting data, background information, and references.	No results stated in abstract.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
128. Jaar BG, Hermann JA, Furth SL, Briggs W, Powe NR. Septicemia in diabetic hemodialysis patients: comparison of incidence, risk factors, and mortality with nondiabetic hemodialysis patients. *Am J Kidney Dis.* 2000;35(2):282-292.	Observational-Tx	4,005 patients	To compare the incidence, risk factors, and mortality associated with septicemia between incident diabetic and nondiabetic HD patients.	Over 7 years, 11.1% of nondiabetic patients and 12.5% of diabetic patients experienced at least one episode of septicemia. Older age and low serum albumin were independent risk factors for septicemia in all patients. In diabetics, white race, peripheral vascular disease, and hemodialysis reuse, particularly in type 1, were independent risk factors. In nondiabetics, coronary artery disease, cerebrovascular disease, and temporary and permanent catheters were associated with an increased risk. In both groups, patients who experienced an episode of septicemia had twice the risk of death from any cause and an eightfold risk of death from septicemia.	2
129. Powe NR, Jaar B, Furth SL, Hermann J, Briggs W. Septicemia in dialysis patients: incidence, risk factors, and prognosis. *Kidney Int.* 1999;55(3):1081-1090.	Observational-Tx	4,918 patients	To examine the incidence, risk factors, and prognosis for septicemia in a large, representative group of U.S. dialysis patients.	Over seven years of follow-up, 11.7% of 4005 HD patients and 9.4% of 913 PD patients had at least one episode of septicemia. Older age and diabetes were independent risk factors for septicemia in all patients. Among HD patients, low serum albumin, temporary vascular access, and dialyzer reuse were also associated with increased risk. Among PD patients, white race and having no health insurance at dialysis initiation were also risk factors. Patients with septicemia had twice the risk of death from any cause and a fivefold to nine fold increased risk of death from septicemia.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
130. Hoen B, Paul-Dauphin A, Hestin D, Kessler M. EPIBACDIAL: a multicenter prospective study of risk factors for bacteremia in chronic hemodialysis patients. *J Am Soc Nephrol.* 1998;9(5):869-876.	Observational-Tx	988 adults	To determine the current incidence of and risk factors for bacteremia in chronic hemodialysis patients in France.	Staphylococcus aureus (n=20) and coagulase-negative staphylococci (n=15) were responsible for most of the 51 bacteremic episodes recorded. The incidence of bacteremia was 0.93 episode per 100 patient-months. Four risk factors for bacteremia were identified: (1) vascular access (catheter vs fistula: RR=7.6; 95% CI, 3.7 to 15.6); (2) history of bacteremia (> or =2 vs no previous episode: RR=7.3; 95% CI, 3.2 to 16.4); (3) immunosuppressive therapy (current vs no: RR=3.0; 95% CI, 1.0 to 6.1); and (4) corpuscular hemoglobin (per 1 g/dl increment: RR=0.7; 95% CI, 0.6 to 0.9). Catheters, especially long-term implanted catheters, were found to be the leading risk factor of bacteremia in chronic hemodialysis patients. There was a trend toward recurrence of bacteremia that was not associated with chronic staphylococcal nasal carriage. Synthetic membranes were not associated with a lower risk of bacteremia in this population of well dialyzed patients, but anemia linked to resistance to erythropoietin appeared to be a possible risk factor for bacteremia.	1

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
131. Hockenhull JC, Dwan K, Boland A, et al. The clinical effectiveness and cost-effectiveness of central venous catheters treated with anti-infective agents in preventing bloodstream infections: a systematic review and economic evaluation. *Health Technol Assess.* 2008;12(12):iii-iv, xi-xii, 1-154.	Meta-analysis	32 trials	To assess the clinical effectiveness and cost-effectiveness of CVCs (CVCs) treated with anti-infective agents in preventing CRBSI (CRBSI).	A total of 32 trials met the clinical inclusion criteria. Seven different types of AI-CVC were identified, with the most frequently tested being chlorhexidine and silver sulfadiazine (externally treated), chlorhexidine and silver sulfadiazine (externally and internally treated) and minocycline rifampicin (internally and externally treated). In general, the trials were of a poor quality in terms of reported methodology, microbiological relevance and control of confounding variables. The pooled result suggests a statistically significant advantage for AI-CVCs in comparison to standard catheters in reducing CRBSI [OR (OR) 0.45, 95% CI (CI) 0.34 to 0.60, 24 studies, I-squared = 0%, fixed effects]. Analysis by subgroups of catheters demonstrates that antibiotic-treated catheters and catheters treated internally and externally decrease CRBSI rates significantly (OR 0.26, 95% CI 0.15 to 0.46, six studies, I-squared = 0%, fixed effects, and OR 0.43, 95% CI 0.26 to 0.70, nine studies, I-squared = 0%, fixed effects, respectively). Catheters treated only externally demonstrate a wider CI and non-significant effect (OR 0.67, 95% CI 0.43 to 1.06, nine studies, I-squared = 0%, fixed effects). A treatment effect was also found for trials with an average duration of between 5 and 12 days, and for the one study with a mean duration of over 20 days. There was a statistically significant treatment effect for both femoral and jugular insertion sites and for those studies reporting a mix of insertion sites. The treatment effect was not observed in trials using exclusively subclavian insertion sites. Of the four trials that compared treated catheters, one reported a benefit of antibiotic-treated catheters over catheters treated externally with chlorhexidine and silver sulfadiazine. All three sensitivity analyses testing for study design differences reported a statistically significant treatment effect. The review was limited owing to the quality of the trials included, marked differences in the definitions and methods of diagnosis of CRBSI, and inconsistent reporting of risk factors and patient population factors.	M

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
132. Wang H, Huang T, Jing J, et al. Effectiveness of different central venous catheters for catheter-related infections: a network meta-analysis. *J Hosp Infect.* 2010;76(1):1-11.	Meta-analysis	48 clinical trials (12,828 CVCs) investigating 10 intervention catheters	To compare the effectiveness of various catheters for prevention of CRI and to evaluate whether specific catheters are superior to others for reducing CRI.	For prevention of CVC colonization, adjusted silver iontophoretic catheters (OR: 0.58; 95% CI: 0.33-0.95), chlorhexidine and silver sulfadiazine catheters (0.49; 0.36-0.64), chlorhexidine and silver sulfadiazine blue plus catheters (0.37; 0.17-0.69), minocycline-rifampicin catheters (0.28; 0.17-0.43) and miconazole-rifampicin catheters (0.11; 0.02-0.33) were associated with a significantly lower rate of catheter colonization compared with standard catheters. For prevention of CRBSI, adjusted heparin-bonded catheters (0.20; 0.06-0.44) and minocycline-rifampicin catheters (0.18; 0.08-0.34) were associated with a significantly lower rate of CRBSI with standard catheters.	M
133. Antonelli M, De Pascale G, Ranieri VM, et al. Comparison of triple-lumen central venous catheters impregnated with silver nanoparticles (AgTive(R)) vs conventional catheters in intensive care unit patients. *J Hosp Infect.* 2012;82(2):101-107.	Experimental-Tx	272 patients	To evaluate the efficacy of CVCs impregnated with silver nanoparticles in a large group of critically ill patients.	The SC group (N = 135) and CC group (N = 137) were similar in terms of clinical and laboratory parameters at baseline, reasons for ICU admission, complications during CVC insertion, and total time with CVC (mean +/- standard deviation; SC 13 +/- 24 vs CC 15 +/- 37 days). No significant intergroup differences were found in CVC colonization rates (SC 32.6% vs CC 30%; *P*=0.7), CRBSI incidence rates (3.36 infections per 1000 catheter-days in both groups), infection-free times (SC 13 +/- 34 vs CC 12 +/- 12 days; *P*=0.85) or ICU mortality (SC 46% vs CC 43%; *P*=0.7).	1
134. Karanlik H, Kurul S, Saip P, et al. The role of antibiotic prophylaxis in totally implantable venous access device placement: results of a single-center prospective randomized trial. *Am J Surg.* 2011;202(1):10-15.	Experimental-Tx	404 patients	To assess whether prophylactic antibiotics could reduce the rate of surgical site infections (SSI) after insertion of TIVAD.	Groups were well matched for all preoperative variables studied, including comorbid conditions. Superficial surgical site infection developed in 5 patients (2.5%) from the antibiotic group and 6 (3%) from the placebo group (*P*=.75). One from each group developed deep surgical site infection. Both patients were readmitted and underwent repeated debridement, which eventually resulted in port loss in 1 patient.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
135. Covey AM, Toro-Pape FW, Thornton RH, et al. Totally implantable venous access device placement by interventional radiologists: are prophylactic antibiotics necessary? *J Vasc Interv Radiol.* 2012;23(3):358-362.	Observational-Tx	1,183 implantable ports in 1,167 patients	To determine the rate of early infection for totally implantable venous access devices (TIVADs) placed without antibiotic prophylaxis.	There were 1,183 ports placed and 13 removed. CLABSIs occurred in seven (0.6%) patients within 30 days of placement. At the time of TIVAD placement, 81 (7%) patients were receiving antibiotics incidental to the procedure. One patient who received an antibiotic the day of implantation developed a CLABSI. Chemotherapy was administered to 148 (13%) patients on the day of placement.	2
136. van de Wetering MD, van Woensel JB. Prophylactic antibiotics for preventing early central venous catheter Gram positive infections in oncology patients. *Cochrane Database Syst Rev.* 2007(1):CD003295.	Meta-analysis	588 patients; 9 trials	To determine the efficacy of administering antibiotics prior to insertion of a TCVC with or without vancomycin/heparin flush technique in the first 45 days after insertion of the catheter to prevent Gram-positive CRI in oncology patients.	We included nine trials with a total of 588 patients. Four reported on vancomycin/teicoplanin prior to insertion of the TCVC compared to placebo, and five trials reported on antibiotic flushing combined with heparin, compared to heparin flushing only. The overall effect of administering an antibiotic prior to insertion of the catheter decreases the number of Gram positive TCVC infections (OR [OR] = 0.42, 95% CI (CI) 0.13 to 1.31), this effect is not significant. Flushing the TCVC with antibiotics and heparin proved to be beneficial (OR = 0.43, 95% CI 0.21 to 0.87). For intraluminal colonization the baseline infection rate is 15% which leads to a number needed to treat (NNT) of 13 (95 % CI 5 to 23).	M
137. McKee R, Dunsmuir R, Whitby M, Garden OJ. Does antibiotic prophylaxis at the time of catheter insertion reduce the incidence of catheter-related sepsis in intravenous nutrition? *J Hosp Infect.* 1985;6(4):419-425.	Experimental-Tx	53 catheters in 45 patients	To determine whether the administration of a single dose of prophylactic vancomycin at the time of catheter insertion would reduce the incidence of catheter-related sepsis.	The mean duration of intravenous feeding was similar in both groups (vancomycin: 17.7 +/- 9.6 days; no vancomycin: 16.5 +/- 8.8 days). Overall, the bacteriologically confirmed catheter-related sepsis was 25% and was not reduced by the prophylactic administration of vancomycin.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
138. Fong IW. Prevention of haemodialysis and peritoneal dialysis catheter related infection by topical povidone-iodine. *Postgrad Med J.* 1993;69 Suppl 3:S15-17.	Experimental-Tx	129 hemodialysis patients; 69 peritoneal dialysis patients	To address the issue of prevention of CRI in hemodialysis and peritoneal dialysis patients.	In a prospective, randomized, open study of 129 hemodialysis patients, exit site infection and bacteremia were significantly greater in the untreated group (18.2% each) than the group treated with povidone-iodine (PVP-I) ointment (4.8% each), $P<0.02$. In nasal carriers of S. aureus, PVP-I resulted in 100% risk reduction of bacteremia and exit site infection ($P<0.05$) and 70% risk reduction of catheter tip infections ($P<0.05$). Preliminary results of an on-going randomized study in patients on intermittent peritoneal dialysis suggest, in the 69 patients so far studied, a reduced S. aureus infection rate in patients who received PVP-I ointment at the catheter exit site (2.9%) compared with the untreated group (8.8%) despite a higher nasal carriage rate in the PVP-I group. Statistical significance has not been demonstrated for these interim results and the study is continuing.	1
139. Johnson DW, MacGinley R, Kay TD, et al. A randomized controlled trial of topical exit site mupirocin application in patients with tunnelled, cuffed haemodialysis catheters. *Nephrol Dial Transplant.* 2002;17(10):1802-1807.	Experimental-Tx	50 patients	To compare the effect of thrice-weekly exit site application of mupirocin (mupirocin group) vs no ointment (control group) on infection rates and catheter survival in patients receiving hemodialysis via a newly inserted, tunneled, cuffed CVC.	Fifty patients were enrolled in the study. Both the mupirocin (n=27) and control (n=23) groups were similar at baseline with respect to demographic characteristics, comorbid illnesses and causes of renal failure. Compared with controls, mupirocin-treated patients experienced significantly fewer catheter-related bacteraemias (7 vs 35%, $P<0.01$) and a longer time to first bacteremia (log rank score 8.68, $P<0.01$). The beneficial effect of mupirocin was entirely attributable to a reduction in staphylococcal infection (log rank 10.69, $P=0.001$) and was still observed when only patients without prior nasal Staphylococcus aureus carriage were included in the analysis (log rank score 6.33, $P=0.01$). Median catheter survival was also significantly longer in the mupirocin group (108 vs 31 days, log rank score 5.9, $P<0.05$). Mupirocin use was not associated with any adverse patient effects or the induction of antimicrobial resistance.	1

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
140. Levin A, Mason AJ, Jindal KK, Fong IW, Goldstein MB. Prevention of hemodialysis subclavian vein catheter infections by topical povidone-iodine. *Kidney Int.* 1991;40(5):934-938.	Experimental-Tx	148 catheters	To evaluate the impact of topical povidone-iodine ointment on the incidence of SCC related infections in hemodialysis patients.	Catheter duration ranged from 2 to 210 days in both groups, with a mean of 38.6 days in T and 36.2 days in C (NS). Exit site (ES) infections were significantly less in T (5%) vs C (18%) (P less than 0.02); tip colonization (TC) was 17% in T vs 36% in C (P less than 0.01), while the incidence of septicemia (S) was also significantly less in T (2%) vs C (17%; P less than 0.01). S. aureus nasal carriers were at a threefold higher risk of SCC related septicemia (0.009/day) than noncarriers (0.003/day; P less than 0.05). The beneficial effect of PI ointment was most evident in this high risk group of S. aureus carriers: ES = 0% T vs 24% C, TC = 12% T vs 42% C, S = 0% T vs 29% C, P less than 0.05. There were no adverse effects of the treatment.	1
141. Deliberato RO, Marra AR, Correa TD, et al. Catheter related bloodstream infection (CRBSI) in ICU patients: making the decision to remove or not to remove the central venous catheter. *PLoS One.* 2012;7(3):e32687.	Observational-Tx	53 patients	To compare the in-hospital mortality when the catheter is removed or not removed in patients with CRBSI.	53 CRBSI (37 diagnosed by the standard method and 16 by the conservative method) were diagnosed during the study period. There was a no statistically significant difference in the in-hospital mortality for the standard vs the conservative method (57% vs 75%, *P*=0.208) in ICU patients.	2
142. Abdelkefi A, Achour W, Ben Othman T, et al. Difference in time to positivity is useful for the diagnosis of catheter-related bloodstream infection in hematopoietic stem cell transplant recipients. *Bone Marrow Transplant.* 2005;35(4):397-401.	Observational-Dx	38 bloodstream infections	To assess the validity of a test based on the earlier positivity of central venous blood cultures in comparison with peripheral blood cultures for predicting catheter-related bacteremia.	A total of 22 patients had catheter-related bacteremias and 16 had noncatheter-related bacteremias, using the catheter-tip culture/clinical criteria as the criterion standard to define catheter-related bacteremia. Differential time to positivity of 120 min or more was associated with 86% sensitivity and 87% specificity.	2

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
143. Raad I, Hanna H, Boktour M, et al. Management of central venous catheters in patients with cancer and candidemia. *Clin Infect Dis.* 2004;38(8):1119-1127.	Observational-Tx	404 cases of candidemia	To review 404 episodes of candidemia that occurred in patients with cancer who have indwelling CVCs and determine by univariate and multivariate analyses the impact of CVC removal at various time points on the outcome of the bloodstream infection.	Of the total 404 cases of candidemia, 241 (60%) were due to a primary source, 111 (27%) were catheter related, and 52 (13%) were secondary cases of candidemia caused by a source other than the catheter. Multivariate analysis showed that catheter removal ≤72 h after onset improved response to antifungal therapy exclusively in patients with catheter-related candidemia (*P*=.04). Clinical characteristics that suggested a noncatheter source for the candidemia were disseminated infection (*P*<.01), previous chemotherapy (*P*<.01), previous corticosteroid therapy (*P*=.02), and poor response to antifungal therapy (*P*<.03).	2
144. Nakazawa N. Infectious and thrombotic complications of central venous catheters. *Semin Oncol Nurs.* 2010;26(2):121-131.	Review/Other-Tx	N/A	To provide a review of the pathogenesis, prevention, and management strategies of infectious and thrombotic complications of CVADs.	No results stated in abstract.	4
145. Wolf HH, Leithauser M, Maschmeyer G, et al. Central venous catheter-related infections in hematology and oncology : guidelines of the Infectious Diseases Working Party (AGIHO) of the German Society of Hematology and Oncology (DGHO). *Ann Hematol.* 2008;87(11):863-876.	Review/Other-Tx	N/A	To present guidelines on CVC-related infections in hematology and oncology.	Positive blood cultures are the cornerstone in the diagnosis of CRIs, while local signs of infection are not necessarily present. Blood cultures should be taken from peripheral blood and from the venous catheter. A shorter time to positivity of catheter blood cultures as compared with peripheral blood cultures supports the diagnosis of a CRI. In many cases, a definite diagnosis requires catheter removal and microbiological analysis. The role plate method with semiquantitative cultures has been established as standard in most laboratories. Antimicrobial treatment of CRI should be directed by the in vitro susceptibility of the isolated pathogen. Primary removal of the catheter is mandatory in S. aureus and Candida infections, as well as in case of tunnel or pocket infections. Future studies will elucidate whether the rate of CRI in neutropenic patients may be reduced by catheters impregnated with antimicrobial agents.	4

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Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
146. Beathard GA. Management of bacteremia associated with tunneled-cuffed hemodialysis catheters. *J Am Soc Nephrol.* 1999;10(5):1045-1049.	Observational-Tx	114 cases	To report the results of a prospective observational series in which catheter management was based on the clinical picture presented by the patient.	A cure rate total of 87.8% for the Xchng group, 75% for the Nutunl group, and 86.5% for the Delay group was seen for the 114 episodes of CRB.	2
147. Duszak R, Jr., Haskal ZJ, Thomas-Hawkins C, et al. Replacement of failing tunneled hemodialysis catheters through pre-existing subcutaneous tunnels: a comparison of catheter function and infection rates for de novo placements and over-the-wire exchanges. *J Vasc Interv Radiol.* 1998;9(2):321-327.	Observational-Tx	119 catheters in 68 patients	To evaluate over-the-wire exchange of catheters through pre-existing subcutaneous tunnels as an alternative to catheter removal and de novo catheter replacement.	Technical success for catheter exchange was 93%. Infection rates were comparable to those of de novo catheter placement: 0.15 and 0.11 infections per 100 catheter days for de novo and exchanged catheters, respectively. Catheter duration of function was not significantly different for de novo vs exchanged catheters: 63% and 51% at 3 months, 51% and 37% at 6 months, and 35% and 30% at 12 months, respectively.	2
148. Robinson D, Suhocki P, Schwab SJ. Treatment of infected tunneled venous access hemodialysis catheters with guidewire exchange. *Kidney Int.* 1998;53(6):1792-1794.	Review/Other-Tx	23 catheter exchanges in 21 patients	To report a cohort of patients with systemic infections associated with cuffed tunneled catheters who were treated with guidewire exchange in addition to intravenous antibiotic therapy.	Four patients (18%) redeveloped bacteremia within 90 days of the exchange. The bacteremias developed at 4, 19, 63 and at 74 days after the exchange.	4
149. Raad I. Management of intravascular catheter-related infections. *J Antimicrob Chemother.* 2000;45(3):267-270.	Review/Other-Tx	N/A	No abstract available.	No abstract available.	4
150. Fortun J, Grill F, Martin-Davila P, et al. Treatment of long-term intravascular catheter-related bacteraemia with antibiotic-lock therapy. *J Antimicrob Chemother.* 2006;58(4):816-821.	Observational-Tx	48 episodes	To evaluate the efficacy of ALT.	A total of 801 long-term intravascular devices were placed in 105 patients during this period. There were 127 episodes of bacteremia documented in these patients, with 92 being CRB. Of these, 48 episodes fulfilled inclusion criteria for the analysis. Nineteen episodes were treated with ALT plus systemic antibiotics, and 29 episodes were treated only with systemic antibiotics. Isolated microorganisms were similar in the two groups. The catheter had to be removed during therapy in one episode in the antibiotic-lock group and in seven episodes in the control group. Relapse of the bacteremia with the same microorganism after stopping therapy was observed in two and three patients in the study group and the control group, respectively. Overall, successful treatment was achieved in 84% and 65% of the episodes in the antibiotic-lock group and the control group, respectively (P=0.27).	2

Radiologic Management of Central Venous Access
EVIDENCE TABLE

Reference	Study Type	Patients/ Events	Study Objective (Purpose of Study)	Study Results	Study Quality
151. Kojic EM, Darouiche RO. Candida infections of medical devices. *Clin Microbiol Rev.* 2004;17(2):255-267.	Review/Other-Tx	N/A	To (i) discuss the formation of Candida biofilms around medical devices and compare them to bacterial biofilms and (ii) review, in a systematic fashion, the impact of Candida infections on commonly used medical devices.	No results states in abstract.	4
152. Hanna H, Afif C, Alakech B, et al. Central venous catheter-related bacteremia due to gram-negative bacilli: significance of catheter removal in preventing relapse. *Infect Control Hosp Epidemiol.* 2004;25(8):646-649.	Observational-Tx	72 cases of catheter-related GNB	To study the characteristics of catheter-related, gram-negative bacteremia (GNB) and the role of CVC (CVC) removal.	Between January 1990 and December 1996, 72 cases of catheter-related GNB were available for review. Most of the patients (67; 93%) had their CVCs removed in response to the bacteremia. Few patients (5; 7%) retained their CVCs and were treated with appropriate antibiotics. When CVCs were removed, only 1 patient (1%) relapsed with the same organism, whereas all 5 patients with retained CVCs relapsed after having responded ($P<.001$). The most commonly isolated organisms were Enterobacter, Klebsiella, Stenotrophomonas, Pseudomonas, and Acinetobacter species. Catheter removal within 72 hours of the onset of the catheter-related GNB was the only independent protective factor against relapse of the infection (OR, 0.13; 95% CI, 0.02-0.75; $P=.02$).	2

Evidence Table Key

Study Quality Category Definitions

- *Category 1* The study is well-designed and accounts for common biases.
- *Category 2* The study is moderately well-designed and accounts for most common biases.
- *Category 3* There are important study design limitations.
- *Category 4* The study is not useful as primary evidence. The article may not be a clinical study or the study design is invalid, or conclusions are based on expert consensus. For example:
  a) the study does not meet the criteria for or is not a hypothesis-based clinical study (e.g., a book chapter or case report or case series description);
  b) the study may synthesize and draw conclusions about several studies such as a literature review article or book chapter but is not primary evidence;
  c) the study is an expert opinion or consensus document.
- M = Meta-analysis

Dx = Diagnostic

Tx = Treatment