**Practice Guidelines for Central Venous Access: Update 2020**

**Supplement 3: Bibliography by Section**

I. Resource preparation

Selection of a sterile environment (e.g., an OR).

Nonrandomized comparative studies

1. Roberts JP, Gollow IJ: Central venous catheters in surgical neonates. J Pediatr Surg 1990; 25:632-634

Observational studies, case reports, or non-pertinent comparison groups

No entries

II. Availability of a standardized equipment set.

Observational studies, case reports, or non-pertinent comparison groups

No entries

III. Use of a trained assistant for central venous catheter placement.

Observational studies, case reports, or non-pertinent comparison groups

No entries

IV. Use of a checklist or protocol for central venous catheter placement and maintenance.

Observational studies, case reports, or non-pertinent comparison groups

1. Chua C, Wisniewski T, Ramos A, Schlepp M, Fildes JJ, Kuhls DA: Multidisciplinary trauma intensive care unit checklist: impact on infection rates. J Trauma Nurs 2010; 17:163-166

V. Bundles that include a checklist or protocol for central venous catheter placement and maintenance.

Randomized controlled trials

No entries

Observational studies, case reports, or non-pertinent comparison groups

1. Ahmed SS, McCaskey MS, Bringman S, Eigen H: Catheter-associated bloodstream infection in the pediatric intensive care unit: A multidisciplinary approach. Pediatr Crit Care Med 2012; 13:e69-72

2. Al-Tawfiq JA, Amalraj A, Memish ZA: Reduction and surveillance of device-associated infections in adult intensive care units at a Saudi Arabian hospital, 2004-2011. Int J Infect Dis 2013; 17:e1207-11

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10. Ceballos K, Waterman K, Hulett T, Makic MB: Nurse-driven quality improvement interventions to reduce hospital-acquired infection in the NICU. Adv Neonatal Care 2013; 13:154-63

11. Dumyati G, Concannon C, van Wijngaarden E, Love TM, Graman P, Pettis AM, Greene L, El-Daher N, Farnsworth D, Quinlan G, Karr G, Ward L, Knab R, Shelly M: Sustained reduction of central line-associated bloodstream infections outside the intensive care unit with a multimodal intervention focusing on central line maintenance. Am J Infect Control 2014; 42:723-30

12. Eggimann P, Harbarth S, Constantin MN, Touveneau S, Chevrolet JC, Pittet D: Impact of a prevention strategy targeted at vascular-access care on incidence of infections acquired in intensive care. Lancet 2000; 355:1864-8

13. Esteban E, Ferrer R, Urrea M, Suarez D, Rozas L, Balaguer M, Palomeque A, Jordan I: The impact of a quality improvement intervention to reduce nosocomial infections in a PICU. Pediatr Crit Care Med 2013; 14:525-32

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23. Hsin HT, Hsu MS, Shieh JS: The long-term effect of bundle care for catheter-related blood stream infection: 5-year follow-up. Postgrad Med J 2017; 93:133-137

24. Hsu YJ, Weeks K, Yang T, Sawyer MD, Marsteller JA: Impact of self-reported guideline compliance: Bloodstream infection prevention in a national collaborative. Am J Infect Control 2014; 42:S191-6

25. Jeong IS, Park SM, Lee JM, Song JY, Lee SJ: Effect of central line bundle on central line-associated bloodstream infections in intensive care units. Am J Infect Control 2013; 41:710-6

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28. Kim JS, Holtom P, Vigen C: Reduction of catheter-related bloodstream infections through the use of a central venous line bundle: Epidemiologic and economic consequences. Am J Infect Control 2011; 39:640-6

29. Klintworth G, Stafford J, O'Connor M, Leong T, Hamley L, Watson K, Kennon J, Bass P, Cheng AC, Worth LJ: Beyond the intensive care unit bundle: Implementation of a successful hospital-wide initiative to reduce central line-associated bloodstream infections. Am J Infect Control 2014; 42:685-7

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Observational studies, case reports, or non-pertinent comparison groups

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PREVENTION OF INFECTIOUS COMPLICATIONS

VI. Intravenous antibiotic prophylaxis.

Randomized controlled trials

No entries

Nonrandomized comparative studies

No entries

Observational studies, case reports, or non-pertinent comparison groups

No entries

VII. Aseptic techniques.

Aseptic preparation (hand washing, sterile full body drapes, sterile gown, gloves, mask, cap, removing rings, shaving hair vs clipping vs no hair removal):

Randomized controlled trials

1. Raad II, Hohn DC, Gilbreath BJ, Suleiman N, Hill LA, Bruso PA, Marts K, Mansfield PF, Bodey GP: Prevention of central venous catheter-related infections by using maximal sterile barrier precautions during insertion. Infect Control Hosp Epidemiol 1994: 15:231-238

Observational studies, case reports, or non-pertinent comparison groups

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2. Smith JW, Egger M, Franklin G, Harbrecht B, Richardson JD: Central line-associated blood stream infection in the critically ill trauma patient. Am Surg 2011; 77:1038-42

Skin preparation.

Chlorhexidine (Hibiclens) vs povidone iodine (Betadine):

Randomized controlled trials

1. Maki DG, Ringer M, Alvarado CJ: Prospective randomised trial of providone-iodine, alcohol, and chlorhexidine for prevention of infection associated with central venous and arterial catheters. Lancet 1991; 338:339-343

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Nonrandomized comparative studies

1. Ohtake S, Takahashi H, Nakagawa M, Uchino Y, Miura K, Iriyama N, Nakayama T, Hatta Y, Takei M: One percent chlorhexidine-alcohol for preventing central venous catheter-related infection during intensive chemotherapy for patients with haematologic malignancies. J Infect Chemother 2018; 24:544-548

2. Pages J, Hazera P, Megarbane B, du Cheyron D, Thuong M, Dutheil JJ, Valette X, Fournel F, Mermel LA, Mira JP, Daubin C, Parienti JJ, Group SS: Comparison of alcoholic chlorhexidine and povidone-iodine cutaneous antiseptics for the prevention of central venous catheter-related infection: A cohort and quasi-experimental multicenter study. Intensive Care Med 2016; 42:1418-26

Observational studies, case reports, or non-pertinent comparison groups

1. Girard R, Comby C, Jacques D: Alcoholic povidone-iodine or chlorhexidine-based antiseptic for the prevention of central venous catheter-related infections: In-use comparison. J Infect Public Health 2012; 5:35-42

2. Humar A, Ostromecki A, Direnfeld J, Marshall JC, Lazar N, Houston PC, Boiteau P, Conly JM: Prospective randomized trial of 10% providone-iodine versus 0.5% tincture of chlorhexidine as cutaneous antisepsis for prevention of central venous catheter infection. Clin Infect Dis 2000; 31:1001-1007

3. Mimoz O, Pieroni L, Lawrence C, Edouard A, Costa Y, Samii K, Brun-Buisson C: Prospective, randomized trial of two antiseptic solutions for prevention of central venous or arterial catheter colonization and infection in intensive care unit patients. Crit Care Med 1996; 24:1818-1823

4. Mimoz O, Villeminey S, Ragot S, Dahyot-Fizelier C, Laksiri L, Petitpas F, Debaene B: Chlorhexidine-based antiseptic solution vs alcohol-based povidone-iodine for central venous catheter care. Arch Intern Med 2007; 167:2066-2072

5. Timsit JF, L'Heriteau F, Lepape A, Francais A, Ruckly S, Venier AG, Jarno P, Boussat S, Coignard B, Savey A: A multicentre analysis of catheter-related infection based on a hierarchical model. Intensive Care Med 2012; 38: 1662-72

Aseptic preparation with vs without alcohol:

Randomized controlled trials

1. Parienti JJ, du Cheyron D, Ramakers M, Malbruny B, Leclerq R, Le Coutour X, Charbonneau P: Alcoholic providone-iodine to prevent central venous catheter colonization: A randomized unit crossover study. Crit Care Med 2004; 32:708-713

Nonrandomized comparative studies

No entries

Observational studies, case reports, or non-pertinent comparison groups

No entries

VIII. Catheter coatings/impregnation (selection of catheter type).

Antibiotic-coated catheters vs no coating:

Randomized controlled trials

1. Bach A, Darby D, Böttiger B, Böhrer H, Motsch J, Martin E: Retention of the antibiotic teicoplanin on a hydromer-coated central venous catheter to prevent bacterial colonization in postoperative surgical patients. Intensive Care Med 1996; 22:1066-1069

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Nonrandomized comparative studies

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2. Lorente L, Lecuona M, Ramos MJ, Jiménez A, Mora ML, Sierra A: The use of rifampicin-miconazole-impregnated catheters reduces the incidence of femoral and jugular catheter-related bacteremia. Clin Infect Dis 2008; 47:1171-1175

3. Ramos ER, Reitzel R, Jiang Y, Hachem RY, Chaftari AM, Chemaly RF, Hackett B, Pravinkumar SE, Nates J, Tarrand JJ, Raad, II: Clinical effectiveness and risk of emerging resistance associated with prolonged use of antibiotic-impregnated catheters: more than 0.5 million catheter days and 7 years of clinical experience. Crit Care Med 2011; 39:245-51

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Observational studies, case reports, or non-pertinent comparison groups

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Silver-impregnated catheters vs no coating:

Randomized controlled trials

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Nonrandomized comparative studies

No entries

Observational studies, case reports, or non-pertinent comparison groups

No entries

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Antbiotic-coated catheters vs chlorhexidine+silver sulfadiazine

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Randomized controlled trials

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Nonrandomized comparative studies

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IX. Selection of catheter insertion site (for prevention of infectious complications).

Internal jugular:

Randomized controlled trials

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Nonrandomized comparative studies

1. Alexandrou E, Spencer TR, Frost SA, Mifflin N, Davidson PM, Hillman KM: Central venous catheter placement by advanced practice nurses demonstrates low procedural complication and infection rates--a report from 13 years of service\*. Crit Care Med 2014; 42: 536-43

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Subclavian:

Randomized controlled trials

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Femoral:

Randomized controlled trials

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Observational studies, case reports, or non-pertinent comparison groups

1. Durbec O, Viviand X, Potie F, Vialet R, Albanese J, Martin C: A prospective evaluation of the use of femoral venous catheters in critically ill adults. Crit Care Med 1997; 25:1986-1989

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4. Venkataraman ST, Thompson AE, Orr RA: Femoral vascular catheterization in critically ill infants and children. Clin Pediatr 1997; 36:311-319

5. Williams JF, Seneff MG, Friedman BC, McGrath BJ, Gregg R, Sunner J, Zimmerman JE: Use of femoral venous catheters in critically ill adults: prospective study. Crit Care Med 1991; 19:550-553

Selecting an insertion site that is not contaminated or potentially contaminated (e.g., burned or infected skin, groin lines, adjacent to tracheostomy site):

Nonrandomized comparative studies

1. Lorente L, Jimenez A, Martin MM, Palmero S, Jimenez JJ, Mora ML: Lower incidence of catheter-related bloodstream infection in subclavian venous access in the presence of tracheostomy than in femoral venous access: prospective observational study. Clin Microbiol Infect 2011; 17: 870-2

2. Lorente L, Jimenez A, Roca I, Martin MM, Mora ML: Influence of tracheostomy on the incidence of catheter-related bloodstream infection in the catheterization of jugular vein by posterior access. Eur J Clin Microbiol Infect Dis 2011; 30: 1049-51

3. Ramos GE, Bolgiani AN, Patino O, Prezzavento GE, Guastavino P, Durlach R, Fernandez Canigia LB, Benaim F: Catheter infection risk related to the distance between insertion site and burned area. J Burn Care Rehabil 2002; 23:266-271

Observational studies, case reports, or non-pertinent comparison groups

1. Franceschi D, Gergind RL, Phillips G, Fratianne RB: Risk factors associated with intravascular catheter infections in burned patients: a prospective, randomized study. J Trauma 1989; 29:811-816

2. Goldstein AM, Weber JM, Sheridan RI: Femoral venous access is safe in burned children: an analysis of 224 catheters. J Pediatr 1997; 130:442-446

3. Friedman BC, Mian MA, Mullins RF, Hassan Z, Shaver JR, Johnston KK: Five-Lumen Antibiotic-Impregnated Femoral Central Venous Catheters in Severely Burned Patients: An Investigation of Device Utility and Catheter-Related Bloodstream Infection Rates. J Burn Care Res 2015; 36: 493-9

X. Catheter fixation.

Suture versus staple or tape:

Randomized controlled trials

1. Rickard CM, Edwards M, Spooner AJ, Mihala G, Marsh N, Best J, Wendt T, Rapchuk I, Gabriel S, Thomson B, Corley A, Fraser JF: A 4-arm randomized controlled pilot trial of innovative solutions for jugular central venous access device securement in 221 cardiac surgical patients. J Crit Care 2016; 36:35-42

2. Vinjirayer A, Jefferson P, Ball DR: Securing central venous catheters: a comparison of sutures with staples. Emerg Med J 2004; 21:582-583

Nonrandomized comparative studies

No entries

Staple versus tape:

Randomized controlled trials

No entries

Nonrandomized comparative studies

No entries

XI. Insertion site dressings (e.g., clear plastic, chlorhexidine, gauze and tape, dermabond, biopatch, antibiotic ointment).

Randomized controlled trials

1. Arvaniti K, Lathyris D, Clouva-Molyvdas P, Haidich AB, Mouloudi E, Synnefaki E, Koulourida V, Georgopoulos D, Gerogianni N, Nakos G, Matamis D, Catheter-Related Infections in ICUG: Comparison of Oligon catheters and chlorhexidine-impregnated sponges with standard multilumen central venous catheters for prevention of associated colonization and infections in intensive care unit patients: a multicenter, randomized, controlled study. Crit Care Med 2012; 40:420-9

2. Biehl LM, Huth A, Panse J, Kramer C, Hentrich M, Engelhardt M, Schafer-Eckart K, Kofla G, Kiehl M, Wendtner CM, Karthaus M, Ullmann AJ, Hellmich M, Christ H, Vehreschild MJ: A randomized trial on chlorhexidine dressings for the prevention of catheter-related bloodstream infections in neutropenic patients. Ann Oncol 2016; 27:1916-22

2. Duzkaya DS, Sahiner NC, Uysal G, Yakut T, Citak A: Chlorhexidine-Impregnated Dressings and Prevention of Catheter-Associated Bloodstream Infections in a Pediatric Intensive Care Unit. Crit Care Nurse 2016; 36:e1-e7

4. Garland JS, Alex CP, Mueller CD, Otten D, Shivpuri C, Harris MC, Naples M, Pellegrini J, Buck RK, McAuliffe TL, Goldmann DA, Maki DG: A randomized trial comparing povidone-iodine to a chlorhexidine gluconate-impregnated dressing for prevention of central venous catheter infections in neonates. Pediatrics 2001; 107:1431-1436

5. Levy I, Katz J, Solter E, Samra Z, Vidne B, Birk E, Ashkenazi S, Dagan O: Chlorhexidine-impregnated dressing for prevention of colonization of central venous catheters in infants and children: a randomized controlled study. Pediatr Infect Dis J 2005; 24:676-679

6. Pedrolo E, Danski MT, Vayego SA: Chlorhexidine and gauze and tape dressings for central venous catheters: a randomized clinical trial. Rev Lat Am Enfermagem 2014; 22:764-71

7. Roberts B, Cheung D: Biopatch: a new concept in antimicrobial dressings for invasive devices. Aust Crit Care 1998; 11:16-19

8. Ruschulte H, Franke M, Gastmeier P, Zenz S, Mahr KH, Buchholz S, Hertenstein B, Hecker H, Piepenbrock S: Prevention of central venous catheter related infections with chlorhexidine gluconate impregnated wound dressings: a randomized controlled trial. Ann Hematol 2009; 88:267-72

9. Timsit JF, Schwebel C, Bouadma L, Geffroy A, Garrouste-Orgeas M, Pease S, Herault MC, Haouache H, Calvino-Gunther S, Gestin B, Armand-Lefevre L, Leflon V, Chaplain C, Benali A, Francais A, Adrie C, Zahar JR, Thuong M, Arrault X, Croize J, Lucet JC: Chlorhexidine-impregnated sponges and less frequent dressing changes for prevention of catheter-related infections in critically ill adults: a randomized controlled trial. JAMA 2009; 301:1231-1241

10. Timsit JF, Mimoz O, Mourvillier B, Souweine B, Garrouste-Orgeas M, Alfandari S, Plantefeve G, Bronchard R, Troche G, Gauzit R, Antona M, Canet E, Bohe J, Lepape A, Vesin A, Arrault X, Schwebel C, Adrie C, Zahar JR, Ruckly S, Tournegros C, Lucet JC: Randomized controlled trial of chlorhexidine dressing and highly adhesive dressing for preventing catheter-related infections in critically ill adults. Am J Respir Crit Care Med 2012; 186:1272-8

Nonrandomized comparative studies

1. Fukunaga A, Naritaka H, Fukaya R, Tabuse M, Nakamura T: Povidone-iodine ointment and gauze dressings associated with reduced catheter-related infection in seriously ill neurosurgical patients. Infect Control Hosp Epidemiol 2004; 25:696-698

2. Guclu E, Karabay O, Ergonenc T, Ergonenc J, Ekerbicer H, Erdem AF: The efficacy of chlorhexidine-impregnated gel dressings for catheter-related bloodstream infections. Acta Medica Mediterranea 2014; 30:1115-1120

3. Karpanen TJ, Casey AL, Whitehouse T, Nightingale P, Das I, Elliott TS: Clinical evaluation of a chlorhexidine intravascular catheter gel dressing on short-term central venous catheters. Am J Infect Control 2016; 44:54-60

4. Moro ML, Viganò EF, Cozzi Lepri A: Risk factors for central venous catheter-related infections in surgical and intensive care units. Infect Control Hosp Epidemiol 1994; 15:253-264

Observational studies, case reports, or non-pertinent comparison groups

1. Conly JM, Grieves K, Peters B: A prospective, randomized study comparing transparent and dry gauze dressings for central venous catheters. J Infect Dis 1989; 159:310-319

2. Wille A, Blusse A, Van Ord Alblas Thewessen EAPM: A comparison of two transparant film-type dressings in central venous therapy. J Hosp Infect 1992; 23:113-121

3. Pfaff B, Heithaus T, Emanuelsen M: Use of a 1-piece chlorhexidine gluconate transparent dressing on critically ill patients. Crit Care Nurse 2012; 32:35-40

4. Pivkina AI, Gusarov VG, Blot SI, Zhivotneva IV, Pasko NV, Zamyatin MN: Effect of an acrylic terpolymer barrier film beneath transparent catheter dressings on skin integrity, risk of dressing disruption, catheter colonisation and infection. Intensive Crit Care Nurs 2018; 46:17-23

5. Scheithauer S, Lewalter K, Schroder J, Koch A, Hafner H, Krizanovic V, Nowicki K, Hilgers RD, Lemmen SW: Reduction of central venous line-associated bloodstream infection rates by using a chlorhexidine-containing dressing. Infection 2014; 42:155-9

6. Wall JB, Divito SJ, Talbot SG: Chlorhexidine gluconate-impregnated central-line dressings and necrosis in complicated skin disorder patients. J Crit Care 2014; 29:1130 e1-4

7. Weitz NA, Lauren CT, Weiser JA, LeBoeuf NR, Grossman ME, Biagas K, Garzon MC, Morel KD: Chlorhexidine gluconate-impregnated central access catheter dressings as a cause of erosive contact dermatitis: a report of 7 cases. JAMA Dermatol 2013; 149:195-9

XII. Catheter maintenance.

Long-term versus short-term catheterization:

Randomized controlled trials

No entries

Nonrandomized comparative studies

1. Bicudo D, Batista R, Furtado GH, Sola A, Medeiros EA: Risk factors for catheter-related bloodstream infection: a prospective multicenter study in Brazilian intensive care units. Braz J Infect Dis 2011; 15:328-31

2. Gil RT, Kruse JA, Thill-Baharozian MC, Carlson RW: Triple-vs single lumen central venous catheters: a prospective study in a critically ill population. Arch Intern Med 1989; 149:1139-1143

3. McLaws ML, Burrell AR: Zero risk for central line-associated bloodstream infection: Are we there yet? Crit Care Med 2012; 40:388-93

4. Moro ML, Viganò EF, Cozzi Lepri A: Risk factors for central venous catheter-related infections in surgical and intensive care units. Infect Control Hosp Epidemiol 1994; 15:253-264

5. Timsit JF, L'Heriteau F, Lepape A, Francais A, Ruckly S, Venier AG, Jarno P, Boussat S, Coignard B, Savey A: A multicentre analysis of catheter-related infection based on a hierarchical model. Intensive Care Med 2012; 38: 1662-72

Observational studies, case reports, or non-pertinent comparison groups

1. Fallat ME, Gallinaro RN, Stover BH, Wilkerson S, Goldsmith LJ: Central venous catheter bloodstream infections in the neonate intensive care unit. J Pediat Surg 1998; 33:1383-1387

2. Pepin CS, Thom KA, Sorkin JD, Leekha S, Masnick M, Preas MA, Pineles L, Harris AD: Risk factors for central-line-associated bloodstream infections: A focus on comorbid conditions. Infect Control Hosp Epidemiol 2015; 36:479-8

Frequency of insertion site inspection for signs of infection:

Randomized controlled trials

No entries

Nonrandomized comparative studies

No entries

Changing catheters:

At specified time intervals versus no specified time intervals

Randomized controlled trials

1. Powell C, Kudsk KA, Kulich PA, Mandelbaum JA, Fabri PJ: Effect of frequent guidewire changes on triple-lumen catheter sepsis. J Parenter Enteral Nutr 1988; 12:462-464

Nonrandomized comparative studies

1. Bozzetti F, Terno G, Bonfanti G, Scarpar D, Scotti A, Ammatuna M, Bonalumi MG: Prevention and treatment of central venous catheter sepsis by exchange via a guidewire. Ann Surg 1982; 198:48-52

Observational studies, case reports, or non-pertinent comparison groups

1. Sheridan RL, Weber JM, Peterson HF, Tompkins RG: Central venous catheter sepsis with weekly catheter change in paediatric burn patients: an analysis of 221 catheters. Burns 1995; 21:127-129

One specified time interval versus another time interval

Randomized controlled trials

1. Bonawitz SC, Hammell EJ, Kirkpatrick JR: Prevention of central venous catheter sepsis: a prospective randomized trial. Am Surg 1991; 57:618-623

2. Kowalewska-Grochowska K, Richards R, Moysa GL, Lam K, Costerton JW, King EG: Guidewire catheter change in central venous catheter biofilm formation in a burn population. Chest 1991; 100:1090-1095

Nonrandomized comparative studies

1. Kagan RJ, Neely AN, Rieman MT, Hardy A, Warner P, Bailey JK, Yakuboff KP: A performance improvement initiative to determine the impact of increasing the time interval between changing centrally placed intravascular catheters. J Burn Care Res 2014; 35:143-7

No entries

Changing a catheter over a wire versus a new site

Randomized controlled trials

1. Kealey GP, Chang P, Heinie J, Rosenquist MD, Lewis RW: Prospective comparison of two management strategies of central venous catheters in burn patients. J Trauma 1995; 38:344-349

2. Michel LA, Bradpiece HA, Randour P, Pouthier F: Safety of central venous catheter change over guidewire for suspected catheter-related sepsis. A prospective randomized trial. Int Surg 1988; 73:180-186

3. Snyder RH, Archer FT, Endy T, Allen TW, Condon B, Kaiser J, Whatmore D, Harrington G, McDermott CJ: Catheter infection: A comparison of two catheter maintenance techniques. Ann Surg 1988; 208:651-653

Nonrandomized comparative studies

1. Armstrong CW, Mayhall CG, Miller KB, Newwome HH, Sugerman HJ, Dalton HP, Hall GO, Gennings C: Prospective study of catheter replacement and other risk factors for infection ofhyperalimentation catheters. J Infect Dis 1986; 154:808-816

2. Badley AD, Steckelberg JM, Wollan PC, Thompson RL: Infectious rates of central venous catheters: comparison between newly placed catheters and those that have been changed. Mayo Clin Proc 1996; 71:838-846

3. O'Mara MS, Reed NL, Palmieri TL, Greenhalgh DG: Central venous catheter infections in burn patients with scheduled catheter exchange and replacement. J Surg Res 2007; 142:341-350

4. Parbat N, Sherry N, Bellomo R, Schneider AG, Glassford NJ, Johnson PD, Bailey M: The microbiological and clinical outcome of guide wire exchanged versus newly inserted antimicrobial surface treated central venous catheters. Crit Care 2013; 17:R184

5. Rupp ME, Lisco SJ, Lipsett PA, Perl TM, Keating K, Civetta JM, Mermel L, Lee D, Dellinger EP, Donahoe M, Giles D, Pfaller MA, Make DG, Sheretz R: 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; 143:570-580

6. Rupp ME, Lisco SJ, Lipsett PA, Perl TM, Keating K, Civetta JM, Mermel L, Lee D, Dellinger EP, Donahoe M, Giles D, Pfaller MA, Make DG, Sheretz R: 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; 143:570-580

Observational studies, case reports, or non-pertinent comparison groups

1. Gregory JA, Schiller WR: Subclavian catheter changes every third day in high risk patients. Am Surg 1985; 51:534-536

2. Kowalewska-Grochowska K, Richards R, Moysa GL, Lam K, Costerton JW, King EG: Guidewire catheter change in central venous catheter biofilm formation in a burn population. Chest 1991; 100:1090-1095

XIII. Aseptic techniques using an existing central line for injection or aspiration (e.g., wiping port with alcohol, not using stopcocks).

Wiping ports with alcohol:

Nonrandomized comparative studies

No entries

Observational studies, case reports, or non-pertinent comparison groups

No entries

Capping stopcocks:

Nonrandomized comparative studies

No entries

Observational studies, case reports, or non-pertinent comparison groups

No entries

Needleless catheter connectors/access ports:

Randomized controlled trials

1. Casey AL, Burnell S, Whinn H, Worthington T, Faroqui MH, Elliott TSJ: A prospective clinical trial to evaluate the microbial barrier of a needleless connector. J Hosp Infect 2007; 65:212-218

2. Casey AL, Worthington T, Lambert PA, Quinn D, Faroqui MH, Elliott TSJ: A randomized, prospective clinical trial to assess the potential infection risk associated with the PosiFlow needleless connector. J Hosp Infect 2003; 54:288-293

3. Lucet JC, Hayon J, Bruneel F, Dumoulin JL, Joly-Juillou ML: Microbiological evaluation of central venous catheter administration hubs. Infect Control Hosp Epidemiol 2000; 21:40-42

4. Yebenes JC, Vidaur L, Serra-Prat M, Sirvent JM, Batlle J, Motje M, Bonet A, Palomar M: 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; 32:291-295

Nonrandomized comparative studies

No entries

Observational studies, case reports, or non-pertinent comparison groups

1. Cookson, ST, Ihrig, M, O'Mara, EM, Denny M, Volk H, Banerjee SN, Hartstein AI, Jarvis WR: Increased bloodstream infection rates in surgical patients associated with variation from recommended use and care following implementation of a needleless device. Infect Control Hosp Epidemiol 1998; 19:23-27

2. Ishizuka M, Nagata H, Takagi K, Kubota K: Needleless closed system does not reduce central venous catheter-related bloodstream infection: A retrospective study. Int Surg 2013; 98:88-93

3. Rupp ME, Sholtz LA, Jourdan DR, Marion ND, Tyner LK, Fey PD, Iwen PC, Anderson JR: Outbreak of bloodstream infection temporally associated with the use of an intravascular needleless valve. Clin Infect Dis 2007; 44:1408-1414

4. Seymour VM, Dhallu TS, Moss HA, Tebbs SE, Elliot TS: A prospective clinical study to investigate the microbial contamination ofa needleless connector. J Hosp Infect 2000; 45:165-168

**PREVENTION OF MECHANICAL TRAUMA OR INJURY**

XIV. Selection of catheter insertion site (for prevention of mechanical trauma or injury).

Internal jugular:

Randomized controlled trials

1. Kaiser CW, Koornick AR, Smith N, Soroff HS: Choice of route for central venous cannulation: Subclavian or internal jugular vein? A prospective randomized study. J Surg Oncol 1981; 17:345-354

2. Kocum A, Sener M, Calıskan E, Bozdogan N, Atalay H, Aribogan A: An alternative central venous route for cardiac surgery: supraclavicular subclavian vein catheterization. J Cardiothorac Vasc Anesth 2011; 25:1018-23

3. Parienti JJ, Mongardon N, Megarbane B, Mira JP, Kalfon P, Gros A, Marque S, Thuong M, Pottier V, Ramakers M, Savary B, Seguin A, Valette X, Terzi N, Sauneuf B, Cattoir V, Mermel LA, du Cheyron D, Group SS: Intravascular Complications of Central Venous Catheterization by Insertion Site. N Engl J Med 2015; 373: 1220-9

Nonrandomized comparative studies

1. Bell J, Goyal M, Long S, Kumar A, Friedrich J, Garfinkel J, Chung S, Fitzgibbons S: Anatomic site-specific complication rates for central venous catheter insertions. J Intensive Care Med 2018

2. Eisenhauer ED, Derveloy RJ, Hastings PR: Prospective evaluation of central venous pressure (CVP) catheters in a large city-county hospital. Ann Surg 1982; 196:560

3. Molgaard O, Nielsen MS, Handberg BB, Jensen JM, Kjaergaard J, Juul N: Routine X-ray control of upper central venous lines: Is it necessary? Acta Anaesthesiol Scand 2004; 48:685-689

4. Sznajder JI, Zveibil FR, Bitterman H, Weiner P, Bursztein S: Central vein catheterization: Failure and complications rates by three percutaneous approaches. Arch Intern Med 1986 146:259-261

5. Timsit JF, Farkas JC, Boyer JM, Martin JB, Misset B, Renaud B, Carlet J: Central vein catheter related thromsosis in intensive care patients: incidence, risk factors and relationship with catheter-related sepsis. Chest 1998; 114:207-213

Observational studies, case reports, or non-pertinent comparison groups

1. Aoki H, Mizobe T, Nozuchi S, Hatanaka T, Tanaka Y: Vertebral artery pseudoaneurysm: A rare compliaction of internal jugular vein catheterization. Anesth Analg 1992; 75:296-298

2. Beilin Y, Bronheim D, Mandelbaum C: Hemothorax and subclavian artery laceration during "J" wire change of a right internal jugular vein catheter. Anesthesiology 1998; 88:1399-1400

3. Belani KG, Buckley JJ, Gordon JR, Castaneda W: Percutaneous cervical central venous placement: A comparison of the internal and external jugular routes. Anesth Analg 1980; 59:40-44

4. Bjorkander M, Bentzer P, Schott U, Broman ME, Kander T: Mechanical complications of central venous catheter insertions: A retrospective multicenter study of incidence and risks. Acta Anaesthesiol Scand 2018

5. Cote CJ, Jobes DR, Schwartz AJ, Ellison N: Two approaches to cannulation of a child's internal jugular vain. Anesthesiology 1979; 50:371-373

6. English IC, Frew RM, Pigott JF, Zaki M: Percutaneous catheterization of the internal jugular vein. Anaesthesia 1969; 24:521-531

7. Ezri T, Szmuk P, Cohen Y, Simon D, Mavor E, Katz J, Geva D: Carotid artery-internal jugular vein fistula: A complication of internal jugular vein catheterization. J Cardiothorac Vasc Anesth 2001; 15:231-232

8. Gamulin Z, Bruckner JC, Forster A, Simonet F, Rouge JC: Multiple complications after internal jugular catheterisation. Anaesth 1986; 41:408-412

9. Goldfarb G, Lebrec D: Percutaneous cannulation of the internal jugular vein in patients with coagulopathies: An experience based on 1,000 attempts. Anesthesiology 1982; 56:321-323

10. Hayashi H, Uchida O, Takaki O, Ohnishi Y, Nakajima T, Kataoka H, Kuro M: Internal jugular vein catheterization in infants undergoing cardiovascular surgery: an anlysis of the factors influencing successful catheterization. Anesth Analg 1992; 74:688-693

11. Iserson KV, Copeland J: Pulmonary and aortic punctures - complications of an attempted internal jugular puncture. J Emerg Med 1984; 1:227-231

12. Ives C, Moe D, Inaba K, Castelo Branco B, Lam L, Talving P, Bass M, Demetriades D: Ten years of mechanical complications of central venous catheterization in trauma patients. Am Surg 2012; 78: 545-9

13. Jain U, Shah KB, Belusko RJ, Kumar P, Foy BK, Montoya A, Rao TK: Subclavian artery laceration and acute hemothorax on attempted internal jugular vein cannulation. J Cardiothorac Vasc Anesth 1991; 5:608-610

14. Khalil KG, Parker FB, Mukherjee N, Webb WR: Thoracic duct injury. A complication of jugular vein catheterization. JAMA 1972; 221:908-909

15. Kua JS, Tan IK: Airway obstruction following internal jugular vein cannulation. Anaesth 1997; 52:776-780

16. Kulvatunyou N, Heard SO, Bankey PE: A subclavian artery injury, secondary to internal jugular vein cannulation, is a predictable right-sided phenomenon. Anesth Analg 2002; 95:564-566

17. Misra SN, Misra AK: Neonatal venous cerebral hemorrhage. Report of two cases. Neurosurg Focus 2003; 15:E5

18. Morgan RNW, Morrel DF: Internal jugular catheterization. A review of a potentially lethal hazard. Anaesthesia 1981; 36:512-517

19. Muralidhar K: Left internal versus right internal jugular vein access to central venous circulation using the Seldinger technique. J Cardiothorac Vasc Anesth 1995; 9:115-116

20. Nicolson SC, Sweeney MF, Moore RA, Jobes DR: Comparison of internal and external jugular cannulation of the central circulation in the pediatric patient. Crit Cer Med 1985; 13:747-749

21. Reeves ST, Baliga P, Conroy JM, Cleaver TL: Avulsion of the right facial vein during double cannulation of the internal jugular vein. J Cardiothorac Vasc Anesth 1995; 9:429-430

22. Reuber M, Dunkley LA, Turton EP, Bell MD, Bamford JM: Stroke after internal jugular venous cannulation. Acta Neurol Scand 2002; 105:235-239

23. Sloan MA, Mueller JD, Adelman LS, Caplan LR: Fatal brainstem stroke following internal jugular vein catheterization. Neurology 1991; 41:1092-1095

24. Tyden H: Cannulation of the internal jugular vein - 500 cases. Acta Anaesth Scand 1982; 26:485-488

25. Zaida NA, Khan M, Naqvi HI, Kamal RS: Cerebral infarct following central venous cannulation. Anaesthesia 1998; 53:186-191

Subclavian:

Randomized controlled trials

1. Kaiser CW, Koornick AR, Smith N, Soroff HS: Choice of route for central venous cannulation: Subclavian or internal jugular vein? A prospective randomized study. J Surg Oncol 1981; 17:345-354

2. Merrer J, De Jonghe B, Golliot F, Lefrant J-Y, Raffy B, Barre E, Rigaud J-P, Casciani D, Misset B, Bosquet C, Outin H, Brun-Buisson C, Nitenberg G: Complications of femoral and subcalvian venous catheterization in critically ill patients. A randomized controlled trial. JAMA 2001; 286:700-707

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Nonrandomized comparative studies

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Observational studies, case reports, or non-pertinent comparison groups

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Femoral:

Randomized controlled trials

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Nonrandomized comparative studies

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Observational studies, case reports, or non-pertinent comparison groups

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XV. Patient positioning.

Trendelenburg versus supine position:

Randomized controlled trials

No entries

Nonrandomized comparative studies (healthy volunteers OK for diameter measurements)

1. Armstrong PJ, Sutherland R, Scott DHT: The effect of position and different manoevers on the internal jugular vein diameter size. Acta Anaesth Scand 1994; 38:229-231

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15. Sayin MM, Mercan A, Koner O, Ture H, Celebi S, Sozubir S, Aykac B: Internal jugular vein diameter in pediatric patients: are the J-shaped guidewire diameters bigger than internal jugular vein? An evaluation with ultrasound. Paediatr Anaesth 2008; 18:745-751

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Observational studies, case reports, or non-pertinent comparison groups

No entries

XVI. Needle insertion and catheter placement.

Selection of catheter type:

Double lumen

Randomized controlled trials

1. Johnson BH, Rypins EB: Single-lumen vs double-lumen catheters for total pArenteral nutrition. A randomized, prospective trial. Arch Surg 1990; 125:990-992

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Nonrandomized comparative studies

No entries

Observational studies, case reports, or non-pertinent comparison groups

No entries

Triple lumen

Randomized controlled trials

1. Farkas JC, Liu N, Bleriot JP, Chevret S, Goldstein FW, Carlet J: Single-versus triple-lumen central catheter-related sepsis: a prospective randomized study in a critically ill population. Am J Med 1992; 93:277-282

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Nonrandomized comparative studies

1. Clark-Christoff N, Watters VA, Sparks W, Snyder P, Grant JP: Use of triple-lumen subclavian catheters for administration or total parenteral nutrition. JPEN J Parenter Enteral Nutr 1992; 16:403-407

2. Gil RT, Kruse JA, Thill-Baharozian MC, Carlson RW: Triple-vs single lumen central venous catheters: a prospective study in a critically ill population. Arch Intern Med 1989; 149:1139-1143

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Observational studies, case reports, or non-pertinent comparison groups

1. Digby S: Fatal respiratory obstruction following insertion of a central venous line. Anaesthesia 1994; 49:1013-1014

2. Maschke SP, Rogove HJ: Cardiac tamponade associated with a multilumen central venous catheter. Crit Care Med 1984; 12:611-613

Cordis

Randomized controlled trials

No entries

Nonrandomized comparative studies

No entries

Selection of a large bore catheter:

Observational studies, case reports, or non-pertinent comparison groups

1. Brown CQ: Inadvertent prolonged cannulation of the carotid artery. Anesth Analg 1982; 61:150-152

2. Digby S: Fatal respiratory obstruction following insertion of a central venous line. Anaesthesia 1994; 49:1013-1014

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5. Kulvatunyou N, Heard SO, Bankey PE: A subclavian artery injury, secondary to internal jugular vein cannulation, is a predictable right-sided phenomenon. Anesth Analg 2002; 95:564-566

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8. Shah PM, Babu SC, Goyal A, Mateo RB, Madden RE: Arterial misplacement of large-caliber cannulas during jugular vein catheterization: case for surgical management. Am Coll Surg 2004;198:939-944

9. Sloan MA, Mueller JD, Adelman LS, Caplan LR: Fatal brainstem stroke following internal jugular vein catheterization. Neurology 1991; 41:1092-1095

10. Zaida NA, Khan M, Naqvi HI, Kamal RS: Cerebral infarct following central venous cannulation. Anaesthesia 1998; 53:186-191

Placement of two lines in the same vein:

Nonrandomized comparative studies

1. Reeves ST, Roy RC, Dorman BH, Fishman RL, Pinosky ML: The incidence of complications after the double-catheter technique for cannulation of the right internal jugular vein in a university teaching hospital. Anesth Analg 1995; 81:1073-1076

Observational studies, case reports, or non-pertinent comparison groups

1. Montes-Tapia F, Rodriguez-Tamez A, Luevanos-Gurrola K, Garza-Alatorre A, de la OCM: Ultrasound- guided placement of double catheter in the right internal jugular vein: Two case reports. Afr J Paediatr Surg 2014; 11:196-8

Use of a Seldinger technique versus a modified Seldinger technique:

Randomized controlled trials

1. Lee YH, Kim TK, Jung YS, Cho YJ, Yoon S, Seo JH, Jeon Y, Bahk JH, Hong DM: Comparison of needle insertion and guidewire placement techniques during internal jugular vein catheterization: The thin-wall introducer needle technique versus the cannula-over-needle technique. Crit Care Med 2015; 43:2112-6

2. Kim E, Kim BG, Lim YJ, Jeon YT, Hwang JW, Kim HC, Choi YH, Park HP: A prospective randomised trial comparing insertion success rate and incidence of catheterisation-related complications for subclavian venous catheterisation using a thin-walled introducer needle or a catheter-over-needle technique. Anaesthesia 2016; 71:1030-6

3. Song IK, Kim EH, Lee JH, Jang YE, Kim HS, Kim JT: Seldinger vs modified Seldinger techniques for ultrasound-guided central venous catheterisation in neonates: a randomised controlled trial. Br J Anaesth 2018; 121:1332-1337

Nonrandomized comparative studies

No entries

Limiting number of insertion attempts:

Randomized controlled trials

No entries

Nonrandomized comparative studies

1. Calvache JA, Rodriguez MV, Trochez A, Klimek M, Stolker RJ, Lesaffre E: Incidence of mechanical complications of central venous catheterization using landmark technique: Do not try more than 3 times. J Intensive Care Med 2016; 31:397-402

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Observational studies, case reports, or non-pertinent comparison groups

1. Sitzmann JV, Townsend TR, Siler MC, Bartlett JG: Septic and technical complications of central venous catheterization: a prospective study of 200 consecutive patients. Ann Surg 1985; 202:766-770

XVII. Guiding and verifying needle, wire and catheter placement.

Static ultrasound versus no ultrasound:

Randomized controlled trials

1. Airapetian N, Maizel J, Langelle F, Modeliar SS, Karakitsos D, Dupont H, Slama M: Ultrasound-guided central venous cannulation is superior to quick-look ultrasound and landmark methods among inexperienced operators: a prospective randomized study. Intensive Care Med 2013; 39:1938-44

2. Alderson PJ, Burrows FA, Stemp LI, Hotby HM: Use of ultrasound to evaluate internal jugular vein anatomy and to facilitate central venous cannulation in paediatric patients. Br J Anaesth 1993; 70:145-148

3. Armstrong PJ, Cullen M, Scott DH: The 'SiteRite' ultrasound machine--an aid to internal jugular vein cannulation. Anaesthesia 1993; 48:319-23

4. Hayashi H, Amano M: Does ultrasound imaging before puncture facilitate internal jugular vein cannulation? Prospective randomized comparison with landmark-guided puncture in ventilated patients. J Cardiothorac Vasc Anesth 2002; 16:572-575

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Observational studies, case reports, or non-pertinent comparison groups

1. Hatfield A, Bodenham A: Portable ultrasound for difficult central venous access. Br J Anaesth 1999; 82:822-826

2. Legler D, Nugent M: Doppler localization of the internal jugular vein facilitates central venous cannulation. Anesthesiology 1984; 60:481-482

3. Machi J, Takeda J, Kakegawa T: Safe jugular and subclavian veinipuncture under ultrasonic guidance. Am J Surg 1987; 153:321-323

Real time ultrasound guidance versus no ultrasound:

Randomized controlled trials

1. Agarwal A, Singh DK, Singh AP: Ultrasonography: a novel approach to central venous cannulation. Indian J Crit Care Med 2009; 13:213-6

2. Airapetian N, Maizel J, Langelle F, Modeliar SS, Karakitsos D, Dupont H, Slama M: Ultrasound-guided central venous cannulation is superior to quick-look ultrasound and landmark methods among inexperienced operators: a prospective randomized study. Intensive Care Med 2013; 39:1938-44

3. Aouad MT, Kanazi GE, Abdallah FW, Moukaddem FH, Turbay MJ, Obeid MY, Siddik-Sayyid M: Femoral vein cannulation performed by residents: a comparison between ultrasound-guided and landmark technique in infants and children undergoing cardiac surgery. Anesth Analg 2010; 111:724-728

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5. Denys BG, Uretsky BF, Reddy PS: Ultrasound-assisted cannulation of the internal jugular vein. A prospective comparison to the external landmark-guided technique. Circulation 1993; 87:1557-62

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8. Grebenik CR, Boyce A, Sinclair ME, Evans RD, Mason DG, Martin B: NICE guidelines for central venous catheterization in children. Is the evidence base sufficient? Br J Anaesth 2004; 92:827-830

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11. Mallory DL, McGee WT, Shawker TH: Ultrasound guidance improves the success rate of internal jugular vein cannulation: a prospective randomized trial. Chest 1990; 98:157-160

12. Milling TJ Jr, Rose J, Briggs WM, Birkhahn R, Gaeta TJ, Bove JJ, Meiniker LA: Randomized, controlled clinical trial of point-of-care limited ultrasonography assistance of central venous cannulation: the Third Sonography Outcomes Assessment Program (SOAP-3) Trial. Crit Care Med 2005; 33:1764-1769

13. Oh AY, Jeon YT, Choi EJ, Ryu JH, Hwang JW, Park HP, Do SH: The influence of the direction of J-tip on the placement of a subclavian catheter: real time ultrasound-guided cannulation versus landmark method, a randomized controlled trial. BMC Anesthesiol 2014; 14:11

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15. Shrestha BR, Gautam B: Ultrasound versus the landmark technique: a prospective randomized comparative study of internal jugular vein cannulation in an intensive care unit. JNMA J Nepal Med Assoc 2011; 51:56-61

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Nonrandomized comparative studies

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Verification of placement:

Ultrasound

Randomized controlled trials

No entries

Observational studies, case reports, or non-pertinent comparison groups

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Manometry versus direct pressure measurement (via pressure transducer)

Randomized controlled trials

No entries

Observational studies, case reports, or non-pertinent comparison groups

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Continuous electrocardiogram

Randomized controlled trials

1. Francis KR, Picard DL, Fajardo MA, Pizzi WF: Avoiding complications and decreasing costs of central venous catheter placement utilizing electrocardiographic guidance. Surg Gynecol Obstet 1992; 175:208-211

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Nonrandomized comparative studies

No entries

Observational studies, case reports, or non-pertinent comparison groups

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Fluoroscopy

Randomized controlled trials

No entries

Nonrandomized comparative studies

No entries

Observational studies, case reports, or non-pertinent comparison groups

1. Ellis PK, Deutsch LS, Kidney DD: Interventional radiological retrieval of a guide-wire entrapped in a greenfield filter - treatment of an avoidable complication of central venous access procedure. Clin Radiol 2000; 55:238-239

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Venous blood gas

Randomized controlled trials

No entries

Nonrandomized comparative studies

No entries

Transesophageal echocardiography

Randomized controlled trials

1. Andropoulos DB, Stayer SA, Bent ST, Campos CJ, Bezold LI, Alvarez M, Fraser CD: A controlled study of transesophageal echocardiography to guide central venous catheter placement in congenital heart surgery patients. Anesth Analg 1999; 89:65-70

Nonrandomized comparative studies

No entries

Observational studies, case reports, or non-pertinent comparison groups

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Chest radiography

Randomized controlled trials

No entries

Nonrandomized comparative studies

No entries

Observational studies, case reports, or non-pertinent comparison groups

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Identification of free aspiration of dark (PO2) non-pulsatile blood

Randomized controlled trials

No entries

Observational studies, case reports, or non-pertinent comparison groups

No entries

**MANAGEMENT OF TRAUMA OR INJURY ARISING FROM CENTRAL VENOUS CATHETERIZATION**

XVIII. Not removing vs removing central venous catheter on evidence of arterial puncture.

Nonrandomized comparative data (case series)

1. Guilbert MC, Elkouri S, Bracco D, Corriveau MM, Beaudoin N, Dubois MJ, Bruneau L, Blair JF: Arterial trauma during central venous catheter insertion: Case series, review and proposed algorithm. J Vasc Surg 2008; 48:918-925

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Observational studies, case reports, or non-pertinent comparison groups

1. Abeysinghe V, Xu JH, Sieunarine K: Iatrogenic injury of vertebral artery resulting in stroke after central venous line insertion. BMJ Case Rep 2017; 2017

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IX. Retained Guidewire

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