Office of Evidence Based Practice (EBP) – Critically Appraised Topic (CAT): Arterial Line Catheter

Specific Care Question In critically ill patients with an arterial line catheter, what are the standards of practice for insertion, maintenance care, and line removal to decrease complications (including infection, pressure injury, and vascular injury) and/or failure (defined as any reason for premature removal)?

Recommendations Based on Current Literature (Best Evidence) Only

A strong recommendation is made for the use of ultrasound guided insertion of arterial line catheters, based on an expert review of current literature by the Department of EBP. The overall certainty in the evidence is low[a]. One systematic review and meta-analysis found that ultrasound guidance versus palpation or doppler auditory assistance to guide arterial line cannulation in pediatric patients resulted in fewer complications.

No recommendation can be made for or against arterial line care maintenance, based on an expert review of current literature by the Department of EBP. The overall certainty in the evidence is very low[a]. While some studies may have reported few complications and/or failures comparing different securement techniques, there was no consistency across studies.

No recommendation can be made for or against any standard for removal of arterial line catheters, based on an expert review of current literature by the Department of EBP. No studies were found that answered this question.

When there is a lack of scientific evidence, standard work should be developed, implemented, and monitored.

Literature Summary

Background

Arterial catheters are commonly used in critically ill patients for frequent blood gas sampling and hemodynamic monitoring (Safdar et al., 2013). An estimated eight million catheters are placed each year in the United States (O'Horo et al., 2014). Of the eight million catheters placed, 10% of pediatric patients with arterial lines will develop a complication with the most common complications being infection and inflammation (King et al., 2008). Arterial line insertion and management is complex with many interdisciplinary clinicians involved (Schults et al., 2020). The purpose of this review is to evaluate current literature around the areas of insertion, maintenance care, and removal.

Study Characteristics

The search for suitable studies was completed in September 2020. T Mullen MSN, RN, ACCNS-P, CCRN reviewed the 13 titles and/or abstracts found in the search and identified[b] seven single studies believed to answer the question. After an in-depth review of the seven studies[b], two of the studies (Healy et al., 2018; Reynolds et al., 2015) were reported in the Gravente, et al. (2020) systematic review (SR) and an additional SR (Aouad-Maroun et al., 2016) was added through manual search. Two SRs (Aouad-Maroun et al., 2016; Gravante et al., 2020) and four cohorts (Hebal et al., 2018; King et al., 2008; Safdar et al., 2013; Schults et al., 2020) were determined to answer the question.

Based on the literature selected, this review reported on risk factors for complications, failures, and blood stream infections (BSI); arterial line insertion using ultrasound; and arterial line securement. No studies reported on arterial line removal.

Summary of Evidence

Risk Factors for Complications, Failures, and/or BSI

Four studies (Hebal et al., 2018; King et al., 2008; Safdar et al., 2013; Schults et al., 2020) reported on risk factors associated with arterial line catheter complications, failures, and/or BSIs (see Table 1).

In a prospective cohort (Schults et al., 2020) of PICU patients with arterial line catheters (N = 89), complications were associated with:

- Arm board immobilization, HR = 2.9, 95% CI [1.02, 8.02]; p = .05
- Higher Pediatric Index of Mortality 3 (PIM3) score, HR = 1.06, 95% CI [1.03, 1.09], p < .01
- Non-2% chlorhexidine antisepsis, HR = 0.32, 95% CI [0.11, 0.96], p = .04

In a retrospective cohort (Hebal et al., 2018) of PICU patients with arterial catheters (*N* = 228), complications were associated with:

- Presence of more than one provider during insertion, *p* = .0007
- Insertion attempts at multiple sites, *p* = .036

One prospective cohort study (Safdar et al., 2013) of adult ICU patients (*N* = 543) found:

- 1% Chlorhexidin-75% alcohol for cutaneous antisepsis or chlorhexidine-impregnated sponge dressing resulted in decreased BSIs, 0.5% versus 2.0%, *RR* = 0.25, 95% CI [0.06, 1.02]
- BSI was associated with duration of catheter placement >6 days, RR = 4.31, 95% CI [1.19, 15.59]
-

In a retrospective cohort (King et al., 2008) of PICU patients with arterial catheters (*N* = 10,394), complications were associated with:

- 62% of complications were associated with infection or inflammation. Although, data for central venous catheters was included with the data
- 1-4 months were compared to the older patients 5-11 months and 1-2 years the *OR* increased *OR* = 1.5, [1.25, 1.82] and *OR* = 1.39, [1.09, 1.68], respectively
- First hospital day and need for cardiac surgery *OR* = 1.31, 95% CI [1.03, 1.68]
- Bone marrow transplant *OR* = 1.79, 95% CI [1.19, 2.70]
- Dialysis *OR* = 1.36, 95% CI [1.05, 1.77]

Certainty of The Evidence for Risk Factors for Complication or Failures. The certainty of the body of evidence was very low based on four factors[a]: *within-study risk of bias*, *consistency among studies, directness of evidence*, and *precision of effect estimates*. The body of evidence was assessed to have serious risk of bias, serious inconsistency, not serious indirectness and not serious imprecision. There is serious risk of bias as three of the studies (Hebal et al., 2018 King et al., 2008; Safdar et al., 2013) were retrospective cohorts, which may result in selection bias. Also, King et al., 2008 had a significant confounding factor of included central venous catheter data which may have accounted for the high number of infections in the data. There is serious inconsistency due to the heterogeneity in risk factors assessed.

***Insertion Ultrasound*.** One systematic review and meta-analysis (Aouad-Maroun et al., 2016) reviewed ultrasound guidance versus palpation or doppler auditory assistance to guide arterial line cannulation in pediatric patients (*N* = 5 RCTs with 444 arterial cannulations). The *RR*, indicated that the intervention (ultrasound guidance) was favorable to the comparators (palpation or doppler auditory assistance) to guide arterial line cannulation on **first** attempts, *RR* = 1.96, 95% CI [1.34, 2.85], *n* = 404 catheters. The *RR* indicated that the intervention (ultrasound guidance) was favorable to the comparators (palpation or doppler auditory assistance) to guide arterial line cannulation within **two** attempts, *RR* = 1.78, 95% CI [1.25, 2.51], *n* = 134 catheters. Also, the *RR* indicated that the intervention was favorable to the comparators for decreased rates of complications (hematoma or ischemia) during radial arterial cannulation, *RR* = 0.20, 95% CI [0.07, 0.60], *n* = 222 catheters.

Certainty of The Evidence for Ultrasound. The certainty of the body of evidence was low based on four factors[a]: *within-study risk of bias*, *consistency among studies, directness of evidence*, and *precision of effect estimates*. The body of evidence was assessed to have serious risk of bias, not serious inconsistency, not serious indirectness and serious imprecision. *Risk of bias was serious due to lack of blinding which could affect the outcome and serious imprecision due to the low number of events.*

Securement. One systematic review (Gravante et al., 2020) that includes five RCT (Edwards et al., 2014; Günther et al., 2016; Healy et al., 2018; Reynolds et al., 2015; Stephenson, 2005) measured effectiveness of dressings and securement devices, (*N = 2270 arterial catheters*) (see Table 1).

Edwards et al. (2014) examined adult (*n* = 224) ICU/OR patients arterial line securement.

- Failure was highest in the **standard polyurethane dressing (SPD)** group (10/47, 21%) compared with the **bordered polyurethane (BPU)** (2/43, 5%) **tissue adhesive** (**TA)** (6/56, 11%), and **sutureless securement device (SSD)** (8/49, 16%) groups.
- Peripheral arterial catheter (PAC) failure was significantly higher for **SPD** compared with **BPU** (*p* = .03).

- There were no infections in any group.

Reynolds et al. (2015) examined adult (*n* = 123) ICU/OR patient arterial line securement.

- Failure was lowest in the **TA group** (2/32, 6.3%) compared with the **BPD** (4/30, 13.3%), **SSD** (5/31, 16.1%), and **SPD** (6/30, 20%) groups
- Infection outcomes were not measured.

Günther et al. (2016) examined adult (*n* = 628) ICU patients arterial line securement of **transparent dressings** compared with **IV Advanced dressing**.

- Incidence rates for complications were not different between the two groups: infectious HR = 0.93, 95% CI [0.62, 1.40], *p* = 0.72; dysfunction HR = 1.04, 95% CI [0.80, 1.35], *p* = 0.79

Healy et al. (2018) examined adults (*n* = 300) ICU patients arterial line securement of **polyurethane adhesive keyhole dressing (Veni-Gard)** compared with an **polyurethan adhesive keyhole dressing with an additional polyurethane semipermeable transparent dressing (OpSite)**.

- Catheter failure was highest with **Veni-Gard**, 65 (60%); **Veni-Gard with OpSite**, 44 (40%)
- Accidental removal: **Veni-Gard**, 27 (87%); **Veni-Gard with OpSite**, 4 (13%)

Stephenson (2005) examined adult (n = 995) ICU patients arterial line securement using a **precision-engineered securement device** compared with **tape and transparent membrane dressing (TMD)**.

- The use of a **precision-engineered securement device** resulted in an unscheduled arterial catheter restart rate of 12.8%, which was down from 25%, *p* < .001.

Certainty of the Evidence for *Securement*. The certainty of the body of evidence was low based on four factors[a]: *within-study risk of bias*, *consistency among studies, directness of evidence*, and *precision of effect estimates*. The body of evidence was assessed to have serious risk of bias, serious inconsistency, serious indirectness and not serious imprecision. *Risk of bias was serious due to lack of blinding which could affect the outcome, serious inconsistency due to the different interventions employed between the studies, and serious indirectness as the patients were adults.*

Identification of Studies

Search Strategy and Results (see Figure 1)

('arterial line'/exp OR ('radial artery' NEAR/3 'line') OR ('brachial artery' NEAR/3 'line') OR ('axillary artery' NEAR/3 'line') OR 'peripheral arterial line':ab,ti OR 'umbilical arterial line':ab,ti OR 'arterial catheter':ab,ti OR 'arterial cannulation':ab,ti OR 'pal':ab,ti) AND 'wound dressing'/exp/mj [humans]/lim

Records identified through database searching *n* = 13

Additional records identified through other sources *n* = 1

Studies Included in this Review

Citation	Study Type
Aouad-Maroun et al. (2016)	SR/MA
Gravante et al. (2020)	SR
Hebal et al. (2018)	Retrospective cohort
King et al. (2008)	Retrospective cohort
Safdar et al. (2013)	Retrospective cohort
Schults et al. (2020)	Prospective cohort

Methods Used for Appraisal and Synthesis

[a]The GRADEpro Guideline Development Tool (GDT) is the tool used to create the Summary of Findings table(s) for this analysis.

[b]The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram depicts the process in which literature is searched, screened, and eligibility criteria is applied (Moher, Liberati, Tetzlaff, & Altman, 2009).

[a]GRADEpro GDT: GRADEpro Guideline Development Tool (2015). McMaster University, (developed by Evidence Prime, Inc.). [Software]. Available from gradepro.org.

[b]Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097 **For more information, visit www.prisma-statement.org.**

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Acronyms Used in this Document

Acronym	Explanation
AGREE II	Appraisal of Guidelines Research and Evaluation II
BPU	Bordered polyurethane
BSI	Blood stream infection
CAT	Critically Appraised Topic
EBP	Evidence Based Practice
HR	Harm risk
PAC	Peripheral Arterial Catheters
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SPD	Standard polyurethan dressing
SSD	Sutureless securement device
TA	Tissue adhesive

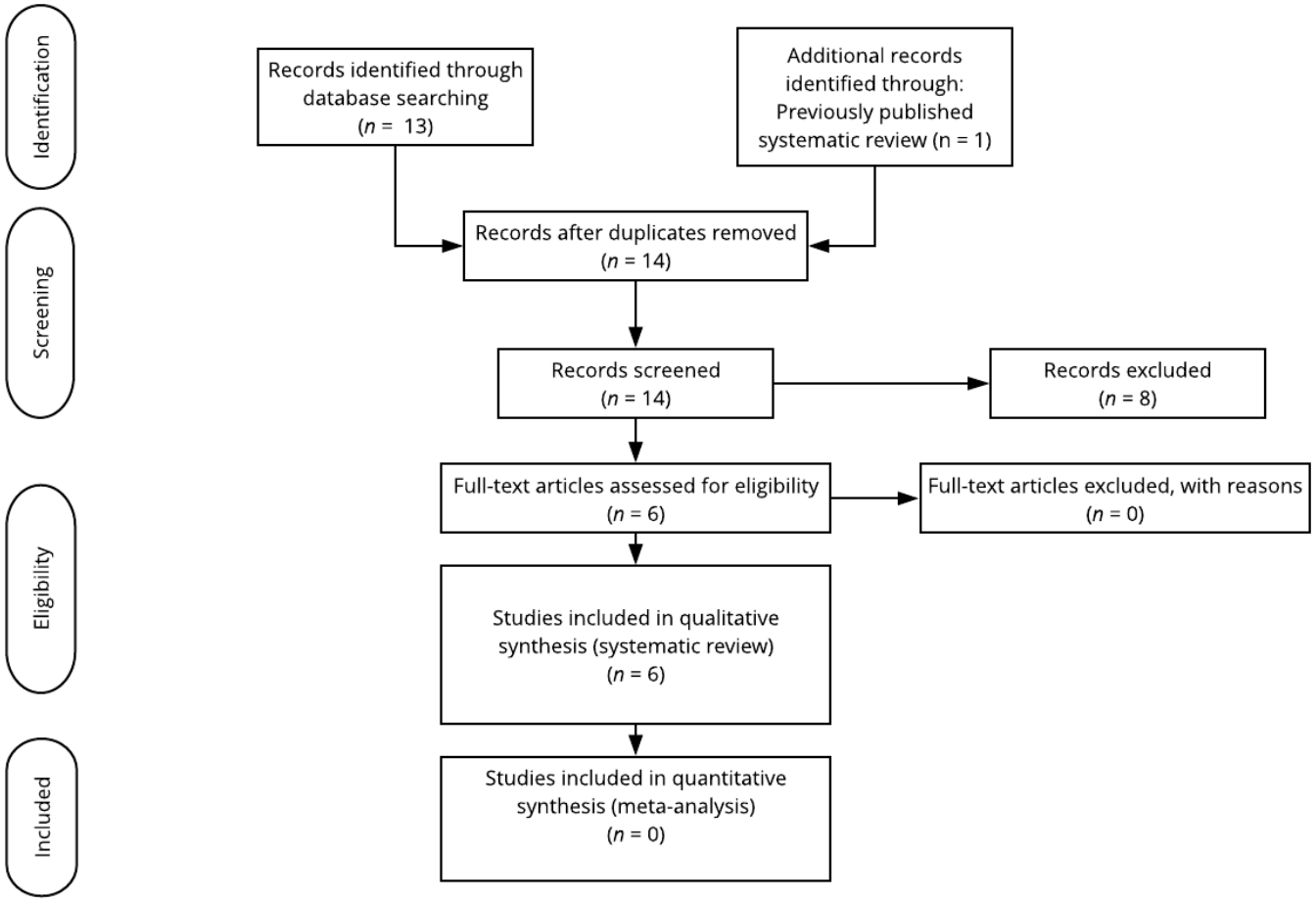
Table 1
Summary of Evidence
**studies included in Gravante et al. (2020) SR*

Authors	Study Design	Sample size	Setting	Adult or Peds	Objective	Findings
Safdar et al., 2013	Cohort (data from 2 RCTs)	543	ICU	Adults	Risk factors: • 1% chlorhexidine – 75% alcohol solution for cutaneous antisepsis or chlorhexidine-impregnated sponge dressing for IV catheters (results were pooled) ○ Incidence of BSI ○ Pathogenesis of BSI Risk factors for BSI	• Mean duration of catheterization for catheter associated BSI versus catheters not associated with BSI: 6.5 days versus 3.5 days, *OR* = 4.31, 95% CI [1.19, 15.59] • Prior antimicrobial use was associated with increased risk of colonization, *OR* = 2.5, 95% CI [1.4, 5.3] • The chlorhexidine-impregnated sponge dressing was found to be efficacious in reducing catheter-related BSI • Chlorhexidine for cutaneous antisepsis was found to be superior to povidone iodine for prevention of catheter-related BSI including arterial catheter Pooled data of the two studies showed a Risk • Reduction (*RR*) = 0.37, 95% CI [0.24, 0.56] and decreased BSI, 0.5% (pooled interventions) versus 2.0% (controls), *RR* = 0.25, 95% CI [0.06, 1.02]
Schults et al., 2020	Prospective cohort	89	PICU	Peds	Risk factors: • Aseptic solution used at insertion: Describe PAC insertion and management practices and associated complications including the following identified practices and complications-	• PACs were primarily inserted for blood sampling (78%) in the radial artery (78%) using ultrasound guidance (67%), with 31% inserted on first attempt • Heparin saline solution was used in 82% of devices. Median catheter dwell was 50.6 hours (IQR 24.0 e 158.0), with PAC failure occurring in 19 devices (20%), at a rate of 40.2 per 1000 catheter days 95% CI [25.7, 63.1] • Arm board immobilization, *HR* = 2.9, 95% CI [1.02, 8.02], *p* =.05, • Higher PIM3 score was associated with PAC failure, *HR* = 1.06, 95% CI [1.03, 1.09], *p* < .01 • Non-2% chlorhexidine antisepsis was associated with a decrease in PAC failure, *HR* = .32, 95% CI [0.11, 0.96], *p* = .04

						• Complication: 10.3% • Infection/Inflammation 61.8% (central lines included in data) • Not specified 14.9% • Embolic or thrombotic issues 7.5%
King et al., 2008	Retrospective cohort	10394	PICU	Peds	Risk factors: • Prevalence and risk factors associated with arterial catheter complication	Predictors: • Age (5-11months versus 1-4 months) *OR* = 1.5, 95% CI [1.25, 1.82] • Age (1-2 years versus 1-4 months) *OR* = 1.39, 95% CI [1.09, 1.68] • First hospital day and need for cardiac surgery *OR* = 1.31, 95% CI [1.03, 1.68] • Bone marrow transplant OR = 1.79, 95% CI [1.19, 2.70] • Dialysis *OR* = 1.36, 95% CI [1.05, 1.77]
Hebal et al., 2018	Retrospective cohort	228	PICU	Peds	Risk factors: • Identify the most common arterial catheter complication	• The placement of the arterial line at multiple sites during the admission and the presence of more than one provider participation in the placement of the arterial catheter increased the likelihood of complication.
Aouad-Maroun et al., 2016	SR (N=5 studies)	444 canulations	ICU, OR	Peds	Insertion: • Assess success rates and complications when using ultrasound guidance in arterial line placement	• Ultrasound guidance significantly increased success rate of cannulation at the first attempt as compared with palpation or the Doppler technique, *RR* = 1.96, 95% CI [1.34, 2.85], 404 catheters • Ultrasound guidance significantly decreased the rate of complications during radial artery cannulation as compared with palpation or the Doppler technique, *RR* = 0.20, 95% CI [0.07, 0.60], 222 catheters • Ultrasound guidance significantly increased radial artery cannulation within the first two attempts as compared with palpation or the Doppler technique, *RR* = 1.78, 95% CI [1.25, 2.51], 134 catheters
Gravante et al., 2020	SR	2270 canulations	ICU	Adults	Objective: Summarize and describe the effectiveness and characteristics of dressings and securement devices for catheter stabilization	• Bordered polyurethane (BPU) dressing plus standard polyurethane dressings • Tissue adhesive (TA) plus standard polyurethane dressing (SPD) • Suture less securement device (SSD) plus standard polyurethane dressing

*Edwards et al., 2014	RCT	224	ICU, OR	Adults	Objective: • Tissue adhesive (TA) with standard polyurethane dressing (SPD) compared with SPD; • Bordered polyurethane (BPU) with SPD; • sutureless securement device (SSD) with SPD	• PAC failure was highest in the standard polyurethane dressing (SPD) group (10/47, 21%) compared with the bordered polyurethane (BPU) (2/43, 5%) • TA (6/56, 11%), and sutureless securement device (SSD) (8/49, 16%) groups • PAC failure was significantly higher for SPD compared with BPD (p = .03) • No infections in any group
*Reynolds et al., 2015	RCT	123	ICU, OR	Adults	Objective: • TA (with SPD) compared with SPD; BPD; and SSD (with SPD)	• PAC failure was lowest in the TA group (2/32, 6.3%) compared with the BPD (4/30, 13.3%), SSD (5/31, 16.1%), and SPD (6/30, 20%) groups • Infection outcomes were not measured
*Günther et al., 2016	RCT	628	ICU	Adults	Objective: • Usual transparent dressings compared with new-generation dressings (the ADVANCED study)	• Incidence rates for complication was equivalent: infectious *HR* = 0.93, 95% CI [0.62, 1.40], p = 0.72: dysfunction *HR* = 1.04 [0.80, 1.35], p = 0.79 • Incidence rate was of 60.9 of 1000 catheter-days • Dysfunction PAC, 12.9/1000 catheter-days; infectious PAC, 14.5/1000 catheter-days • Accidental catheter removal was identified in 71 cases (3.2% of all catheters, density incidence of 6.7/1000 catheter-days).
*Healy et al., 2018	RCT	300	ICU	Adults	Objective: • The usual care group (polyurethane adhesive keyhole dressing (Veni-Gard)) compared with the intervention treatment group (additional polyurethane semipermeable transparent dressing (OpSite transparent waterproof film, 10 cm 12 cm)	• Catheter failure was highest in usual care, 65 (60%); intervention treatment, 44 (40%) • Blocked: usual care, 35 (50%); intervention treatment, 35 (50%) • Accidental removal: usual care, 27 (87%); intervention treatment, 4 (13%) • Infection: usual care, 35 (50%); intervention treatment, 35 (50%) • Restraints: usual care, 17 (11%); intervention treatment, 8 (6%) • Sedated: usual care, 58 (38%); intervention treatment, 41 (30%) • Agitation: usual care, 15 (10%); intervention treatment, 10 (7%)
*Stephenson 2005	RCT	995	ICU	Adults	Objective: • Securement device compared with tape transparent membrane dressing	• During the control period, the rate of unscheduled arterial catheter restarts was 25% • During the study phase, the rate of unscheduled arterial catheter restarts was 12.8% (p < .001) • Cost of reinsertion: securement device was $17.87; transparent membrane dressing was $10.78.

Figure 1
Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRIMSA)[b]



Characteristics of Intervention Studies

Aouad-Maroun (2016)

Design	Quantitative Synthesis
Objective	To assess first attempt success rates and complication rates when ultrasound guidance is used for arterial line placement in the pediatric population, as compared with traditional techniques (palpation, Doppler auditory assistance), at all potential sites for arterial cannulation (left or right radial, ulnar, brachial, femoral or dorsalis pedis artery).
Methods	**Criteria for considering studies for this review** • **Types of studies:** Randomized controlled clinical trials (RCTs) • **Participants:** Pediatric patients, infants, and adolescents (one month to 18 years of age) undergoing arterial line placement • **Target Condition(s):** Measure first attempt success rate, rate of complications (hematoma, ischemic damage), and successful cannulation within the first two attempts when using ultrasound guidance, pulse palpation, or Doppler auditory assistance to place an arterial line. **Search methods for identification of studies** • **Electronic databases searched:** ○ Ovid platform from inception to January 2016 ○ Cochrane Central Register of Controlled Trials (CENTRAL; 2016, Issue 1) ○ MEDLINE ○ Embase ○ ClinicalTrials.gov, inception to January 2016 ○ Current Controlled Trials metaRegister (www.controlled-trials.com) inception to January 2016 ○ EU Clinical Trials register (www.clinicaltrialsregister.eu) inception to January 2016 ○ World Health Organization (WHO) International Clinical Trials Registry Platform inception to January 2016 • **Search strategy employed:** Detailed search terms can be found in appendices 1, 2, and 3 • **Searching other resources:** Reference lists of retrieved included trials, related systematic or other reviews and health technology assessment reports were reviewed for inclusion **Data collection and analysis** • **Inclusion criteria:** Pediatric patients, infants, and adolescents (one month to 18 years of age) undergoing arterial line placement • **Exclusion criteria:** neonates were excluded • **Population:** Age 0 to 18 years • **Setting:** Hospitalized patients • **Study Design:** RCTs • **Data collection process:** Two reviewers assessed the studies independently using the data extraction form found in Appendix 4. Results were compared and disagreements were resolved by consensus or with the assistance of a third reviewer. • **Assessment of the certainty of the evidence:** GRADE • **Data Synthesis and analysis:** RevMan 5.3 was used with random-effects modeling for categorical data and continuous data. The inverse variance statistical method was used for continuous data. ○ **Overall Effect Size** ▪ Dichotomous data: risk ratios (RR) or hazard ratios (HR) with 95% confidence intervals (CI)

	▪ Continuous data when the same scale was employed for the same outcome: mean difference (MD) with 95% CI ▪ Continuous data when different scales were employed for the same outcome: standardized mean differenc (SMD) ○ **Heterogenity** ▪ Visually inspected forest plots ▪ Standard Chi^2 test with significance level 0.1 ▪ I^2 statistic of 50% or more is indicative of considerable level of statistical heterogeneity ○ **Summary of findings table and GRADE** ▪ Quality of the evidence was classified as either high, moderate, low, and very low (this takes the study design, risk of bias, imprecision, inconsistency, indirectness, publication bias, effect size, dose-response effect and confounding into account)
Results	**Study Selection (actual results/data)** **Number of articles identified:** *N* = 241 **Full-text articles assessed for eligibility:** *n* = 6 ○ **Studies included in qualitative synthesis:** *n* = 5 **Synthesis of quality of evidence**: • First attempt success rate: moderate • Rate of complications (hematoma or ischemia): moderate • Successful cannulation within the first two attempts: moderate **Synthesis of quantitative evidence:** • First attempt success rate overall effect size; *n* = 404 catheters ○ Ultrasound guidance significantly increased success rate of cannulation at the first attempt as compared with palpation or the Doppler technique ○ *RR* = 1.96, 95% CI [1.34, 2.85] ○ Heterogeneity: Chi^2 = 3.89, df = 3 (*P* = 0.27); I^2 = 22.91% • Rate of complications (hematoma or ischemia); *n* = 222 catheters ○ Ultrasound guidance significantly decreased the rate of complications during radial artery cannulation as compared with palpation or the Doppler technique ○ *RR* = 0.20, 95% CI [0.07, 0.60] ○ Heterogeneity: Chi^2 = 0, df = 1 (P = 1); I^2 = 0% • Successful cannulation within the first two attempts; *n* = 134 catheters ○ Ultrasound guidance significantly increased radial artery cannulation within the first two attempts as compared with palpation or the Doppler technique ○ *RR* = 1.78, 95% CI [1.25, 2.51] ○ Heterogeneity: Chi^2 = 0.2, df = 1 (*P* = 0.66); I^2 = 0%
Discussion	**Limitations** • There was imprecision due to relatively small number of events and some level of risk of bias within each of the five studies.
Funding	**Funding:** No information was provided regarding funding, and no conflicts of interest were declared.

Gravante et al., (2020)

Design	Quantitative Synthesis
Objective	**SR objective:** Summarize and describe the effectiveness and characteristics of dressings and securement devices for catheter stabilization.

Methods	**Criteria for considering studies for this review**
	• **Types of studies:** Adult patients (age > 18 years)
	  ○ No studies were excluded based on quality evaluation or risk of bias
	• **Participants:** Adults with Peripheral Arterial Catheters (PAC)
	• **Target Condition(s):** Reduction of complications resulting from inadequate catheter stabilization at the level of the skin
	
	Search methods for identification of studies
	• **Electronic databases searched:** MEDLINE, CINHAL, Cochrane, EMBASE, OvidSP, 1970 to 2018
	• **Search strategy employed:**
	  ○ Subject headings and keywords: "arterial catheter," "arterial cannulation," "peripheral arterial catheter," "dressing," "securement device," "fixing method," and "sutureless."
	  ○ Use of Boolean operators "AND" and "OR"
	  ○ Use of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement to guide article selection and reporting
	  ○ Each full-text article was examined by 2 independent researchers, and any disagreement was resolved by a third independent researcher.
	  ○ No studies were excluded based on quality evaluation or risk of bias
	• **Searching other resources (such as reference list):** Possibly employed, four included articles stemmed from "another query"
	
	Data collection and analysis
	• **Inclusion criteria:**
	  ○ Use of PAC dressings or securement devices, based on ICU admission or operating theaters with invasive monitoring
	  ○ Italian and English, full text available
	  ○ Studies which had either PAC dislodgement or PAC failure
	• **Exclusion criteria:**
	  ○ Pediatric and neonatal studies
	  ○ Articles without abstracts
	• **Population:** Adults
	• **Setting:** Hospital ICU or operating theater with invasive monitoring
	• **Study Design:** Not specified-RCTs
	• **Data collection process:** Not specified
	• **Assessment of the certainty of the evidence-:** The quality evaluation of the studies followed information adapted from the Mixed Methods Appraisal Tool (MMAT) of Pluye and the use of Joanna Briggs Institute (JBI) Critical Appraisal Tool for randomized controlled trials (RCTs)
	• **Data Synthesis:** Not specified

	○ **Overall Effect Size** Not specified ○ **Heterogeneity:** Not measured, studies were categorized as heterogeneous. ○ A risk of bias table is included
Results	**Study Selection (actual results/data)** **Number of articles identified:** *N* = 626 **Full-text articles assessed for eligibility:** *n* = 157 ○ **Studies included in qualitative synthesis:** *n* = 5 **Synthesis of quality of evidence** (strength of evidence): Studies were of good quality (based on the MMAT) but difficult to compare due to heterogeneity **Synthesis of quantitative evidence:** ○ **Overall Effect Size:** Not specified ○ **Heterogeneity:** A meta-analysis was not possible because there was high heterogeneity related to type of dressing or securement device used.
Discussion	**Summary of evidence** Of the five different studies considered, there were three distinct types of interventions: • A comparison of three dressings or securement devices ○ Bordered polyurethane (BPU) dressing plus standard polyurethane dressings ○ Tissue adhesive (TA) plus standard polyurethane dressing (SPD) ○ Sutureless securement device (SSD) plus standard polyurethane dressing • Transparent dressings compared with standard treatment dressings • Comparison of securement devices to transparent polyurethan dressings Two outcomes were studied in this SR: • PAC failure (5 studies) • PAC dislodgement (4 studies) There is no strong evidence to suggest that one dressing or securement device product for PAC is more effective than any other dressings. It is important to secure PAC (vs covering with gauze) to prevent dislodgement. Much information on intravenous catheter securement is available. **Table 2: Effectiveness and characteristics of dressing and securement devices for catheter stabilization**

Authors	Study Design	Sample size	Setting	Products Evaluated and Outcome Measure	Findings
Edwards et al., 2014	RCT	224	ICU, OR	**Product Measured:** TA (with SPD) compared with SPD; BPD (with SPD); SSD (with SPD) **Outcome:** PAC failure (composed of complete dislodgement, occlusion [monitor failure, inability	PAC failure was highest in the SPD group (10/47, 21%) compared with the BPD (2/43, 5%), TA (6/56, 11%), and SSD (8/49, 16%) groups. PAC failure was significantly higher for SPD compared with BPD (p = .03). No infections in any group

				to infuse or leakage], pain, local or blood infection)	
Reynolds et al., 2015	RCT	123	ICU, OR	**Product Measured:** TA (with SPD) compared with SPD; BPD; and SSD (with SPD) **Outcome:** PAC failure (composed of complete dislodgement, occlusion, phlebitis, infection [either local or CRBSI]).	PAC failure was lowest in the TA group (2/32, 6.3%) compared with the BPD (4/30, 13.3%), SSD (5/31, 16.1%), and SPD (6/30, 20%) groups. Infection outcomes were not measured.
Günther et al., 2016	RCT	628	ICU	Product Measured: Usual transparent dressings compared with new-generation dressings (the ADVANCED study) **Outcome:** Incidence rates of dysfunction (composed of complete dislodgement, accidental catheter removal, infection).	Incidence rate was of 60.9 of 1000 catheter-days. Dysfunction PAC, 12.9/1000 catheter-days; infectious PAC, 14.5/1000 catheter-days. Accidental catheter removal was identified in 71 cases (3.2% of all catheters, density incidence of 6.7/1000 catheter-days).
Healy et al., 2018	RCT	300	ICU	**Product Measured:** The usual care group had a polyurethane adhesive keyhole dressing (Veni-Gard) compared with the intervention treatment group that had an additional polyurethane semipermeable transparent dressing (OpSite transparent waterproof film, 10 cm 12 cm **Outcome:** PAC failure, blocked, accidental removal, restraints, sedated, agitation.	Catheter failure was highest in usual care, 65 (60%); intervention treatment, 44 (40%); blocked: usual care, 35 (50%); intervention treatment, 35 (50%); accidental removal: usual care, 27 (87%); intervention treatment, 4 (13%); infection: usual care, 35 (50%); intervention treatment, 35 (50%); usual care, 3 (38%); intervention treatment, 5 (63%); restraints: usual care, 17 (11%); intervention treatment, 8 (6%); sedated: usual care, 58 (38%); intervention treatment, 41 (30%); agitation: usual care, 15 (10%); intervention treatment, 10 (7%).
Stephenson et al., 2005	RCT	995	ICU	**Product Measured:** Securement device compared with tape transparent membrane dressing **Outcome:** Rate of unscheduled PAC restarts and cost.	During the control period, the rate of unscheduled arterial catheter restarts was 25%. During the study phase, the rate of unscheduled arterial catheter restarts was 12.8% ($p < .001$). Cost of reinsertion: securement device was $17.87; transparent membrane dressing was $10.78.

BPD: Bordered polyurethane dressing
CRBI: Catheter-related bloodstream infection
SPD: standard polyurethane dressing
SSD: sutureless securement device

	TA: tissue adhesive **Limitations:** Studies were heterogenous. Minimal recommendations made.
Funding	**Funding:** Not specified

Hebal et al., 2018

Methods	**Cohort**
Participants	**Participants:** Children =/< 18 years of age that were admitted **Setting:** Ann and Robert H. Lurie Children's Hospital of Chicago, IL pediatric intensive care unit (PICU). **Number enrolled into study:** *N* = 228 • **Group 1, Line complication:** *n* = 75 • **Group 2, No line complication:** *n* = 153 **Gender, males (as defined by researchers):** • **Group 1:** *n* = 45 (60%) • **Group 2:** *n* = 54 (35%) **Race / ethnicity or nationality (as defined by researchers):** • Not reported. **Age, mean/median in months/years** Age group — Total 1-4 months — 85 (25%) 5-11 months — 40 (12%) 1-2 years — 53 (16%) 3-4 years — 14 (4%) 5-10 years — 49 (28%) 11-18 years — 96 (28%) **Inclusion Criteria:** • Children =/< 18 years of age admitted for any indication with arterial line(s) placed in the PICU. **Exclusion Criteria:** • Umbilical arterial lines • Inadequate documentation of line placement • Arterial lines placed in the operating room by anesthesiologists and/or surgeons **Covariates Identified:** • None reported.
Interventions	Chart review and data collection of patients with arterial lines
Outcomes	**Primary outcome(s):** • Identify the most common arterial catheter complication * • Determine if previously reported risk factors were predictive of these complications in the pediatric population. **Safety outcome(s):** • None reported. *Outcomes of interest to the CMH CPG /CAT development team
Results	**Results:**

- The data examined direct clinical data, including provider notes.
- Inclusion of non-life-threatening complications, such as line malfunctions and bleeding, increased the incidence of complications in the study. For this reason, complication rate reported in the literature are lower than the 33% rate reported in the study.
- The placement of the arterial line at multiple sites during the admission and the presence of more than one provider participation in the placement of the arterial catheter increased the likelihood of complication.
- The authors data corresponds with the current literature, which reports that less than 1% of patients with arterial lines experience a line-related bloodstream infection.
- This study concurs with studies showing that the insertion site itself has no effect on the risk of complications; however, insertion attempts at multiple sites increase the complication risk.

Arterial catheter complications

	Total	*Breakdown of Multiple*	
N	106 (100%)	*Multiple*	*12 (100%)*
Line malfunctions	63 (59%)	*Line malfunctions*	*12 (100%)*
Bleeding	17 (16%)	*Bleeding*	*7 (58%)*
Multiple	12 (11%)	*Hematoma*	*5 (42%)*
Infiltration	9 (8%)	*Infiltration*	*2 (17%)*
Hematoma	4 (4%)	*Vessel thrombosis*	*1 (8%)*
Purulent Drainage	1 (1%)	*Purulent Drainage*	*0 (0%)*
Infection	0 (0%)		

Risk factors for arterial catheter complications

Chi Square Analysis	Statistic	P-Value
Gender	.532	.466
Age group	5.035	.412
Diagnosis	3.227	.521
Race/ethnicity	6.136	.179
Hypoxia	3.775	.052
>1 practitioner	11.851	.001
Multiple placement attempts	2.281	.131
Mean arterial pressure	1.835	.607
Medications	8.561	.036
Attempts at >1 site	1.276	.259
Indication for placement	4.826	.185
Site	13.311	.010
Catheter size	1.127	.952
Vessel identification technique	4.023	.259
Insertion technique	1.312	.519
Line duration (days)	3.520	.172

Limitations:

- Single-center study with a small cohort; results may not be generalizable
- Poor provider documentation in the form of absence of detailed records
- The number of uncaptured complications since many of the variables require voluntary entry

King et al., 2008

Methods	**Cohort** identifying risk factors associated with arterial catheterization complications
Participants	**Participants:** 10,394 pediatric patients discharged between January 1st, 2000 to March 31st, 2005 and identified from the Pediatric Health Information System database **Setting:** Thirty-three children's hospitals PICU units within the Child Health Corporation of America **Number enrolled into study:** *n* = 10,394 • Group 1 (Complications): *n* = 1,072 • Group 2 (No Complications): *n* = 9,322 **Gender, males (as defined by researchers):** • Group 1 (Complications): *n* = 52.9% • Group 2 (No Complications): *n* = 56.2% **Race / ethnicity or nationality (as defined by researchers):** • Group 1 (Complications), White, non-Hispanic: *n* = 43.9% • Group 1 (Complications), Black: *n* = 20.2% • Group 1 (Complications), Hispanic: *n* = 21.8% • Group 1 (Complications), Other: *n* = 14.0% • Group 2 (No Complications), White, non-Hispanic: *n* = 48.8% • Group 2 (No Complications), Black: *n* = 24.2% • Group 2 (No Complications), Hispanic: *n* = 15.1% • Group 2 (No Complications), Other: *n* = 11.9% **Age, mean/years/SD:** • Group 1 (Complications), 1-4 months: *n* = 17.4% (5.2 [6.0]) • Group 1 (Complications), 5-11 months: *n* = 16.1% (5.2 [6.0]) • Group 1 (Complications), 1-2 years: *n* = 18.9% (5.2 [6.0]) • Group 1 (Complications), 3-4 years: *n* = 8.7% (5.2 [6.0]) • Group 1 (Complications), 5-10 years: *n* = 14.0% (5.2 [6.0]) • Group 1 (Complications), 11-18 years: *n* = 25.2% (5.2 [6.0]) • Group 2 (No Complications), 1-4 months: *n* = 17.8% (5.8 [5.9]) • Group 2 (No Complications), 5-11 months: *n* = 11.2% (5.8 [5.9]) • Group 2 (No Complications), 1-2 years: *n* = 16.3% (5.8 [5.9]) • Group 2 (No Complications), 3-4 years: *n* = 9.1% (5.8 [5.9]) • Group 2 (No Complications), 5-10 years: *n* = 18.3% (5.8 [5.9]) • Group 2 (No Complications), 11-18 years: *n* = 27.3% (5.8 [5.9]) **Inclusion Criteria:** • Age 1 month to 18 years • Required admission to a pediatric intensive care unit (PICU) • Received an arterial line placement for monitoring purposes • Hospitalized for >/= 1 day following arterial line placement

	Exclusion Criteria: • <1 month of age • >18 years of age • Never admitted to the PICU • Did not receive arterial line placement • Hospitalized for <1 day following arterial line placement • Death • Poor data entry and thus data was unable to be extracted for the study **Covariates Identified:** • None reported by author(s)
Interventions	**Both (Group 1 & 2):** Arterial line placement was performed
Outcomes	**Primary outcome(s):** • Prevalence of and risk factors associated with arterial catheter insertion including thrombosis, embolism, and infection **Secondary outcome(s):** • No secondary outcomes stated or reported **Safety outcome(s):** • No safety outcomes stated or reported
Results	**Results:** • **Group 1 (Complications):** *n* = 1,072 ○ Infection: *n* = 724 (61.8%) ○ Complications of vascular device: *n* = 175 (14.9%) ○ Mechanical complication: *n* = 165 (14.1%) ○ Arterial thrombosis, or embolus: *n* = 88 (7.5%) ○ Other vascular complication: *n* = 18 (1.5%) ○ Nerve injury: *n* = 2 (0.2%) • **Group 2 (No Complications):** *n* = 9,322 **Limitations:** • Complications were identified using the Pediatric Health Information System and searching for ICD-9 diagnostic codes. Failure to identify the appropriate diagnostic code could limit the study results. • The author(s) reported that due to the simplicity of ICD-9 coding they were unable to also review central venous catheter associated complications at the same time.

Safadar et al., 2013

Methods	**Cohort -** Arterial catheters in two randomized trials in 1998 and 2000 were studied prospectively
Participants	**Participants:** Patients participating in two prospective randomized trials between 1998 and 2000 **Setting:** The patient population was highly susceptible to nosocomial infection with multiple comorbidities, including critical illness (mean APACHE II score = 23.0), multiple invasive devices and procedures, and hypoalbuminemia. All patients were cared for in a 24-bed medical-surgical ICU **Number enrolled into study:** • **Group 1** 1% chlorhexidine – 75% alcohol solution for cutaneous antisepsis or chlorhexidine-impregnated sponge dressing for IV catheters (results were pooled)**:** *n = 834* catheters (a total of 543 patients) • **Group 2:** Not reported on in this study **Gender, males (as defined by researchers):** • **Group 1:** *n* = 355 (65%) • **Group 2:** Not reported on in this study **Race / ethnicity or nationality (as defined by researchers):** • Not specified **Age, mean/median in months/years** • **Group1:** 60 +/- 18 years • **Group 2:** not reported on in this study **Inclusion Criteria:** • Patients highly susceptible to nosocomial infection with multiple comorbidities, including critical illness multiple invasive devices and procedures, and hypoalbuminemia. • Medical Surgical ICU Patients **Exclusion Criteria:** • Not specified **Covariates Identified:** • Univariate analysis of potential risk factors was undertaken using the pooled control groups of the two randomized trials, using Chi-squared or Fisher's exact test for categorical variables and Student's t-test for means. • Due to the limited number of catheter-related BSIs (N ¼ 11), a robust multi-variable model could not be constructed. • P-values <0.05 were considered significant. All statistical analyses were performed using SAS Version 8.1
Interventions	Data analyzed from two previously RCT studies. • **Group 1:** 1% chlorhexidine – 75% alcohol solution for cutaneous antisepsis or chlorhexidine-impregnated sponge dressing for IV catheters (results were pooled) • **Group 2:** Povidone iodine used as agent for cutaneous antisepsis
Outcomes	**Primary outcome(s):** • Incidence of BSI

	• Pathogenesis of BSI • Risk factors for BSI **Secondary outcome:** • Pooled analysis of previous interventions
Results	**Results:** • Mean duration of catheterization for catheter associated BSI versus catheters not associated with BSI: 6.5 days versus 3.5 days, OR = 4.31, 95% CI [1.19, 15.59] • Prior antimicrobial use was associated with increased risk of colonization, *OR* = 2.5, 95% CI [1.4, 5.3] • The chlorhexidine-impregnated sponge dressing was found to be efficacious in reducing catheter-related BSI • Chlorhexidine for cutaneous antisepsis was found to be superior to povidone iodine for prevention of catheter-related BSI including arterial catheters • Pooled data of the two studies showed a Risk Reduction (RR) of 0.37, 95% CI [0.24, 0.56] and decreased BSI, 0.5% (pooled interventions) versus 2.0% (controls), RR = 0.25, 95% CI [0.06, 1.02]. **Limitations:** • This study does not differentiate well between the control group vs. the intervention groups. Could not find the total numbers of the control group they were comparing the intervention group to.

Schults et al., 2020

Methods	Prospective Cohort, observational study
Participants	**Participants:** Pediatric patients requiring a peripheral arterial catheter (PAC) **Setting:** Single center observational study conducted October 2017 to January 2018 at a tertiary referral pediatric facility in Queensland, Australia **Number PAC enrolled into study:** *N* = 100 (100 PAC in 89 patients) **Gender, males (as defined by researchers):** *n* = 55 (55%) **Race / ethnicity or nationality (as defined by researchers):** not described by authors **Age, median in months (range/IQR):** 7.1 (0.4 – 79.6) **Inclusion Criteria:** • Age 0 to 16 years • Required pediatric intensive care unit (PICU) admission • Required peripheral arterial catheter (PAC) insertion **Exclusion Criteria:** • Patient was an external transfer with a PAC already in situ • Patient required an emergency out-of-hours PAC insertion **Covariates Identified:** • Primary diagnosis • Mode of PICU admission • PICU length of stay
Interventions	No intervention. This was an observational study
Outcomes	**Primary outcome(s):** Describe PAC insertion and management practices and associated complications including the following identified practices and complications- • PAC dwell time • Number of PAC insertion attempts, defined as insertion of the needle through the skin, a successful insertion was defined as pulsatile blood flow noted from the PAC • PAC failure, defined as PAC failure before the completion of necessary therapy • Accidental dislodgement, where the body of the PAC partially or completely leaves the artery • Poor aspiration, where the clinician experiences difficulty aspiration blood • Blockage, where the clinician is unable to flush or aspirate the PAC • Poor trace, where there is dampening of the arterial pressure waveform **Secondary outcome(s):** Determine patient and clinical characteristics associated with risk of PAC successful insertion vs. failure included- • Insertion location • Indication

	• Ultrasound use • Insertion site • Device details • Antiseptic solution • Number of attempts • PAC dressing and securement • PAC fluid and insertion complications; hematoma, arterial spasm • PAC management; sampling frequency, PAC fluid, and arm board immobilization **Safety outcome(s):** • Risk of mortality using the Pediatric Index of Mortality 3 (PIM3)

Results	**Results:**
	• PAC insertion and management practices can be found in the article's Supplementary Material 3.
	• Number of insertion attempts
	  ○ 1; *n* = 29 (29%)
	  ○ 2 or more; *n* = 69 (69%)
	• Associations between multiple insertion attempts and patient and device characteristics [Supplementary material 2]
	  ○ None of the *p* values demonstrated statistical significance
	• Insertion complications
	  ○ Hematoma; *n* = 2 (2%)
	  ○ Arterial spasm; *n* = 4(4%)
	  ○ None; *n* = 94 (94%)
	• All-cause failure; *n* = 19 (20.0%)
	• Failure reasons
	  ○ Poor trace; *n* = 10 (10.53%)
	  ○ Blocked; *n* = 6 (6.32%)
	  ○ Accidental dislodgement; *n* = (4.21%)
	  ○ Poor aspiration; *n* = 3 (3.16%)
	  ○ Other; *n* = 1 (1.05%)
	• Associations between PAC failure and patient and device characteristics reported as hazard ratios (HRs) and 95% confidence intervals (CIs)
	  ○ PIM3; 1.06 (1.03 – 1.09) $p < 0.01$
	  ○ Immobilized with arm board; 2.83 (1.05 – 7.63) $p = 0.04$
	  ○ Aseptic solution used at insertion (2% chlorhexidine); 0.32 (0.11 – 0.96) $p = 0.04$
	Limitations:
	• Note regarding gender reporting. This is reported in Table 1. This math doesn't make sense. 55/89 patients = 61.8%. Their math seems to be performed on number of PAC instead of number of patients.

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References marked with an asterisk indicate studies included the meta-analysis

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