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Prevention of catheter-related infection: which catheter, which access and which insertion technique should be chosen?*

Prévention des infections liées aux cathéters : quel cathéter, quelle voie et quelle technique d'insertion choisir ?

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Abstract Central venous and arterial catheters are commonly used in critically ill patients. Such catheters may entail mechanical and infectious complications. Catheter-related infections result in a high rate of morbidity and mortality and elevated costs. Numerous contributions have been made in the prevention of catheter-related infections, and the present review focuses on which catheter, which access and which insertion technique should be used. Regarding vascular access, some sites have shown higher risk of catheter-related bloodstream infections (CRBSI), such as the internal jugular site with tracheostomy and the femoral access site. With respect to which catheter should be used, there is evidence that catheters impregnated with rifampicin-(minocycline or miconazole) and chlorhexidine-silver sulfadiazine reduce the risk of CRBSI. These impregnated catheters could be considered in the following circumstances: vascular access channelling with increased risk of CRBSI (such as the internal jugular with tracheostomy or femoral access), immunocompromised patients or patients with disorders of skin integrity. Regarding the choice of insertion technique, there is evidence that ultrasound guidance may decrease cannulation failure and complication rates.

Keywords Catheter · Venous · Arterial · Prevention · Impregnated · Ultrasounds · Bloodstream · Femoral · Subclavian · Jugular · Radial · Cubital · Brachial · Dorsalis pedis

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Résumé Les cathéters veineux centraux et artériels sont souvent utilisés chez les patients de réanimation. Ces cathéters peuvent engendrer des complications infectieuses et mécaniques. L'infection liée au cathéter est associée à une morbimortalité élevée et à un surcoût important. Cette revue générale s'intéresse à l'impact du type de cathéter, du site d'insertion et de la technique de cathétérisme sur la survenue d'infection liée au cathéter. Concernant le site d'insertion du cathéter, certains sites ont été identifiés comme facteurs de risque de bactériémie liée au cathéter, tels que le site jugulaire en présence d'une canule de trachéotomie et le site fémoral. Le choix du type de cathéter influence également l'incidence de colonisation et d'infection liées au cathéter. Les cathéters imprégnés d'agents anti-infectieux (minocycline–rifampicine ou rifampicine–miconazole) ou antiseptiques (*chlorhexidine*–sulfadiazine argentique) sont associés à une réduction de l'incidence d'infection liée au cathéter. L'utilisation de ces cathéters pourrait être proposée dans les circonstances suivantes : cathéter tunnelisé chez un patient à risque d'infection liée au cathéter (par exemple accès jugulaire interne avec trachéotomie ou accès fémoral), patients immunodéprimés ou souffrant de lésions cutanées. L'utilisation de l'échographie permet de réduire le taux d'échec et les complications mécaniques.

Mots clés Cathéter · Veineux · Artériel · Prévention · Imprégnés · Bactériémie · Fémoral · Sous-clavier · Jugulaire · Radial · Cubital · Brachial · Dorsal · Pédieux

Introduction

Central venous and arterial catheters are commonly used in critically ill patients [1]. Such catheters may entail mechanical and infectious complications. The interest in catheter-related infection lies in attributable morbidity and mortality and the costs involved [2]. Numerous contributions have been made in the field to prevent catheter-related infections, and the present review focuses on certain aspects of prevention, namely which catheter, which access and which insertion technique should be used.

Which central venous catheter access

Different central venous catheter accesses

A strategy that may help to reduce the incidence of catheter-related infection is based on the choice of venous access. Some studies have found higher catheter tip colonization in femoral than in jugular and subclavian accesses [3–5], in femoral than in subclavian accesses [6,7] and in jugular than in subclavian accesses [7,8].

In relation to the incidence of catheter-related bloodstream infections (CRBSI) associated with different central venous catheter (CVC) accesses, in a study carried out by our team including 2595 venous catheters (917 subclavian, 1390 jugular and 288 femoral catheters), we found a higher CRBSI incidence density for femoral than for jugular (8.34 vs. 2.99 events of CRBSI/1000 catheter days, $p = 0.002$) and subclavian accesses (8.34 vs. 0.97 events of CRBSI/1000 catheter days, $p < 0.001$) and higher for jugular than for subclavian access (2.99 vs. 0.97 events of CRBSI/1000 catheter days, $p = 0.005$) [9].

A systematic review recently published by Marik et al. [10], including two randomized controlled trials (RCT) and eight cohort studies, found no significant difference in the risk of CRBSI between the femoral and subclavian sites, and between the femoral and internal jugular sites. However, it is not clear what criteria motivated the decision to exclude from the analysis two studies comparing femoral and internal jugular sites. Including these two studies, the risk of CRBSI was higher in femoral than in internal jugular sites (risk ratio = 1.90; 95% confidence interval (CI) = 1.21–2.97; $p = 0.005$) [11].

The same systematic review [10] found no significant difference in the risk of deep venous thrombosis between the femoral and subclavian/jugular sites. However, some explanations about the two RCTs included in the analysis are necessary. In the RCT published by Merrer et al. [6], 289 patients were randomly assigned to central venous catheterization at either the femoral site ($n = 145$) or the subclavian site ($n = 144$). Femoral catheterization was associated with a higher incidence of overall thrombotic complications (21.5 vs. 1.9%; $p < 0.001$) and complete thrombosis of the vessel (6 vs. 0%; $p = 0.01$). Femoral catheterization was the only risk factor for thrombotic complications (odds ratio = 14.42; 95% CI = 3.33–62.57; $p < 0.001$). In the RCT conducted by Parienti et al. [12], 750 patients were assigned to central venous catheterization at either the femoral site ($n = 370$) or the jugular site ($n = 366$); the analysis of deep venous thrombosis showed no significant differences between the femoral and jugular groups (8/76 (10.5%) vs. 17/75 (22.7%); $p = 0.16$).

Different internal jugular venous accesses

Another aspect in relation to CRBSI, according to CVC site, is the influence of the different internal jugular venous accesses, which has scarcely been studied. Our team conducted a study comparing 515 internal jugular venous catheters by central access and 169 by posterior access; we found a higher incidence of CRBSI in the central access group than in the posterior access group (4.8 vs. 1.2 events of CRBSI/1000 catheter days; odds ratio = 3.9; 95% CI = 1.1–infinite; $p = 0.03$) [13]. This was probably due to the lower contamination by oropharyngeal secretions in the posterior access group. As the patients are placed in a semirecumbent position (by elevating the head of the bed) and the puncture site for posterior access is higher than that used for central access, oropharyngeal secretions reach the central access more easily than the posterior access due to gravity. The semirecumbent position is used to decrease the risk of oesophageal reflux and subsequent aspiration, as recommended in the guidelines for the prevention of ventilator-associated pneumonia of the Society for Healthcare Epidemiology of America/Infectious Diseases Society of America (SHEA/IDSA) [14].

After the study demonstrated the influence of the jugular access in the incidence of CRBSI [13], we carried out other analyses comparing CRBSI rates between femoral and central internal jugular accesses [15], and between posterior internal jugular and subclavian venous accesses [16].

As there was a higher incidence of CRBSI in femoral than in jugular sites [9,10], higher in central than in posterior jugular access [13] and in all the studies included in the systematic review by Marik et al. [10], the internal jugular access used (posterior, central or anterior) was not specified; we believed it could be interesting to compare the incidence of CRBSI between the femoral and central jugular accesses. We carried out a study including 208 femoral catheters and 515 central internal jugular venous catheters and found a higher incidence of CRBSI in femoral than in central internal jugular venous access (9.52 vs. 4.83 events of CRBSI/1000 catheter days; risk ratio = 1.93; 95% CI = 1.03–3.73; $p = 0.04$) [15].

Similarly, as there was a higher incidence of CRBSI associated with jugular than with subclavian sites [9] and the relevant studies included in the systematic review by Marik et al. [10] did not specify which internal jugular access was used, we aimed to compare CRBSI rates between the subclavian and posterior jugular accesses. We carried out an analysis of 877 subclavian and 169 posterior internal jugular venous accesses and found no differences in the incidence of CRBSI (1.02 vs. 1.21 events of CRBSI/1000 catheter days; $p = 0.99$) [16].

Tracheostomy

There are scarce data about the influence of tracheostomy on the incidence of catheter-related infection [17–20]. In a study by Michel et al. [17] with 390 subclavian catheters, patients with tracheostomy had a higher incidence of catheter-tip colonization compared with those without tracheostomy (34 vs. 7%). In a study by Dusan et al. [18] with 219 catheters sited in subclavian or jugular accesses, patients with tracheostomy also had a higher incidence of catheter-tip colonization compared with those without tracheostomy (24 vs. 13%). In a study by Garnacho-Montero et al. [19] with 1211 subclavian or jugular catheters, tracheostomy was found to be an independent risk factor for CRBSI. In another study by our team, we analyzed a total of 515 internal jugular venous catheters (52 with tracheostomy and 463 without tracheostomy) and 877 subclavian venous catheters (89 with tracheostomy and 788 without tracheostomy). We found a higher incidence of CRBSI in patients with tracheostomy than in those without tracheostomy (11.25 vs. 1.43 events of CRBSI/1000 catheter days; odds ratio = 7.99; 95% CI = 4.38–infinite; $p < 0.001$) and a higher incidence of CRBSI in patients with tracheostomy using the jugular access than with subclavian access (21.64 vs. 5.11 events of CRBSI/1000 catheter days; odds ratio = 4.23; 95% CI = 1.44–infinite; $p = 0.01$) [20].

After the finding of the influence of tracheostomy on the incidence of CRBSI at subclavian and jugular accesses, we believed it could be interesting to compare the incidence of CRBSI between central internal jugular venous catheters in the presence of tracheostomy and femoral venous catheters. We included 52 central internal jugular catheters with tracheostomy and 208 femoral catheters and found a higher incidence of CRBSI in patients with central internal jugular catheters than in those with femoral site catheters (21.64 vs. 9.52 events of CRBSI/1000 catheter days; risk ratio = 2.27; 95% CI = 1.04–4.97; $p = 0.04$) [21].

We also carried out another analysis to compare the incidence of CRBSI between the subclavian venous catheter site in the presence of tracheostomy ($n = 147$) and the femoral venous catheter site ($n = 313$). We found a lower incidence of CRBSI in subclavian venous catheters in the presence of tracheostomy than in femoral venous catheters (3.9 vs. 10.1 events of CRBSI/1000 catheter days; odds ratio = 0.39; 95% CI = 0.001–0.910; $p = 0.03$) [22].

Finally, we also performed another analysis to determine the influence of the presence of tracheostomy on CRBSI rates in patients with posterior jugular catheters. We included 16 catheterizations with tracheostomy and 153 catheterizations without tracheostomy and found a higher incidence of CRBSI in posterior jugular access in patients with tracheostomy than in those without tracheostomy (13.24 vs. 0 events of CRBSI/1000 catheter days; odds ratio = 23.92; 95% CI = 1.86–infinite; $p = 0.008$) [23].

The Centers for Disease Control (CDC) and IDSA guidelines for the prevention of intravascular catheter-related infections recommend [24]: the avoidance of the femoral vein (Category IA) and the use of the subclavian site rather than jugular or femoral sites to minimize the risk of infection for non-tunneled CVC placement (Category IB). There is no recommendation about the presence of tracheostomy and the different jugular venous access sites.

On the basis of published findings, I suggest the following central venous catheter sites to minimize the risk of CRBSI: internal jugular by posterior access without tracheostomy or subclavian without tracheostomy, internal jugular by central access without tracheostomy, subclavian with tracheostomy, femoral, internal jugular by posterior access with tracheostomy and finally internal jugular by central access with tracheostomy.

Which arterial catheter access

There are scarce data about arterial catheter-related infection according to the different sites. In a review by Scheer et al. [25], the three most commonly used arterial cannulation sites were closely examined. The review included a total of 19,617 radial, 3899 femoral and 1989 axillary artery catheterizations. Major complications (such as permanent ischaemic damage, sepsis and pseudoaneurysm formation) occurred in less than 1% of the cases, and rates were similar for the radial, femoral and axillary arteries. The authors commented that other arteries employed for catheterization, such as the brachial, dorsal pedis, ulnar, tibial and temporal arteries, have been used without serious complications, but data were not reported. The authors opted not to perform statistical analyses because the studies selected in the review did not report data on all the different arterial catheter sites.

In some studies comparing different arterial accesses, no significant differences in the incidence of arterial catheter-related infection were found [26–31]. One study found a higher incidence of arterial catheter colonization in femoral than in radial and cubital sites [32]. An important limitation of these studies is the small sample size.

Our team conducted a study including 2949 arterial catheters (2088 radial, 112 brachial, 131 dorsalis pedis and 618 femoral catheters) [33]. We found a higher incidence of arterial catheter-related infection in femoral than in radial access (1.92 vs. 0.25 events/1000 catheter days; odds ratio = 1.9, 95% CI = 1.15–3.41; $p = 0.009$) and no other statistically significant differences. After this study, we increased the number of catheters and found a higher incidence of arterial catheter-related infection in 1085 femoral than in 174 dorsalis pedis accesses (p = 0.01) [34], 141 brachial accesses (p = 0.02) [35] and 449 cubital accesses (p = 0.02) [36].

The CDC and IDSA guidelines for the prevention of intravascular catheter-related infections published in 2011 recommended that the use of the radial, brachial or dorsalis pedis sites is preferred over the femoral or axillary sites of insertion to reduce the risk of infection in adults (Category IB) [24]. I agree with the recommendation on avoiding the arterial femoral access.

Which catheter

A proposed strategy to reduce the incidence of CRBSI is the use of CVCs impregnated with different antimicrobial agents, such as chlorhexidine-silver sulfadiazine (CHSS), minocycline-rifampicin, cefazolin, vancomycin, heparin, chlorhexidine, silver, platinum and carbon.

A meta-analysis by Veenstra et al. [37], which included 11 RCT and 2603 catheters, found a lower incidence of CRBSI with the use of first-generation (only the external surface was impregnated) CHSS-impregnated catheters compared with non-impregnated catheters (odds ratio = 0.56; 95% CI = 0.37–0.84; p = 0.005). However, some RCTs performed after this meta-analysis reported that second-generation (both external and internal surfaces impregnated) CHSS-impregnated catheters showed a lower incidence of catheter-tip colonization than non-impregnated catheters, but there were no significant differences in the incidence of CRBSI [38–40].

Another meta-analysis by Falagas et al. [41], which included 3452 CVCs from 8 RCTs, showed decreased CRBSI with the use of rifampicin-impregnated catheters (rifampicin-minocycline in seven RCTs and rifampicin-miconazole (RM) in one RCT) compared with non-coated catheters.

Our team performed a study to determine the efficacy of RM-impregnated catheters to decrease the incidence of CRBSI [42]. We analyzed 184 femoral (73 RM and 111 standard catheters) and 241 central jugular venous catheters (114 RM and 127 standard catheters). We found a lower incidence of CRBSI with RM-impregnated catheters than with standard catheters in femoral access (0 vs. 8.62 events of CRBSI/1000 catheter days, odds ratio = 0.13, 95% CI = 0.00–0.86; p = 0.03) and in central internal jugular access (0 vs. 4.93 events of CRBSI/1000 catheter days, odds ratio = 0.13, 95% CI = 0.00–0.93; p = 0.04).

A multicentre RCT by Darouiche et al. [43] found that the use of minocycline-rifampin-impregnated catheters (n = 356) was associated with a lower rate of CRBSI than CHSS-impregnated catheters (n = 382) (0.3 vs. 3.4%; p < 0.002).

A review by Ramritu et al. [44] found that first-generation CHSS and minocycline-rifampicin-impregnated catheters reduced the risk of CRBSI; however, second-generation CHSS-impregnated catheters, cefazolin, vancomycin, heparin, chlorhexidine, silver, platinum and carbon-impregnated catheters have not been found to reduce the risk of CRBSI.

The use of antimicrobial or antibiotic-impregnated catheters has been found to decrease the incidence of CRBSI and catheter-related cost in some cost-effectiveness analyses [45–47]. The mean additional cost due to CRBSI in the studies included in these cost-effectiveness analyses was approximately $10,000; and in some studies this was as high as $40,000 [48] and $71,000 [49] due mainly to increased hospital stay of 24 and 22 days respectively. In these cost-effectiveness studies, the catheter-related cost included the increase of hospital stay and this varied greatly between the different studies. However, there were no studies reporting catheter-related cost excluding the cost due to increased hospital stay. Thus, the objective of two studies carried out by our team was to determine the immediate catheter-related cost (including only the cost of CVC, diagnosis of CRBSI and antimicrobials for the treatment of CRBSI) using RM or standard catheters in femoral access [50] and in jugular venous access with tracheostomy [51]. In the femoral venous access analysis, which included 184 RM and 190 standard catheters, we found a higher incidence of CRBSI with standard than with RM catheters (8.61 vs. 0 CRBSI episodes/1000 catheter-days; odds ratio = 19.26; 95% CI = 3.24–infinite; p < 0.001) and a higher immediate catheter-related cost per day with standard catheters than with RM catheters (€18.22 ± 53.13 vs. 12.61 ± 8.38; p < 0.001) [50]. In the analysis of the jugular venous access with tracheostomy, which included 68 RM and 79 standard catheters, we found a lower incidence of CRBSI with RM than with standard catheters (0 vs. 20.16 CRBSI episodes/1000 catheter-days; odds ratio = 0.05; 95% CI = 0.001–0.32; p < 0.001) and a lower immediate catheter-related cost per day with RM than with standard catheters (€11.46 ± 6.25 vs. 38.11 ± 77.25; p < 0.001) [51].

The CDC and IDSA guidelines for the prevention of intravascular catheter-related infections published in 2011 recommended the use of a CHSS or minocycline-rifampicin-impregnated catheter in patients whose catheter is expected to remain in place >5 days and if the CRBSI rate has not decreased after the implementation of a comprehensive strategy to reduce it (Category IA); and the preventive strategy should include at least the following three components: educating persons who insert and maintain catheters, use of maximal sterile barrier precautions and a >0.5% chlorhexidine preparation with alcohol for skin antisepsis during catheter insertion [24]. I have some comments about the CDC and IDSA recommendations regarding this issue. First, the guidelines recommended CHSS-impregnated catheters without specifying which generation of CHSS-impregnated catheter is recommended. This recommendation is based on RCTs showing that second-generation CHSS-impregnated catheters reduced the incidence of catheter-tip colonization [38–40]. In these RCTs there were no significant differences in the incidence of CRBSI with the use of second-generation CHSS-impregnated catheters; however, in all of them there was a tendency to lower CRBSI with antimicrobial catheters, and there is no published meta-analysis including these studies. On the other hand, there is evidence that first-generation CHSS-impregnated catheters reduced CRBSI according to the results of one meta-analysis [37]. Second, the CDC and IDSA guidelines recommended the use of minocycline-rifampicin-impregnated catheters. This recommendation is based on two RCTs showing that minocycline-rifampicin-impregnated catheters decreased CRBSI [52,53]; however, the guidelines do not mention one meta-analysis with respect to this issue [41]. In that meta-analysis, including these two RCTs [52,53] and another four RCTs, it was found that minocycline-rifampicin-impregnated catheters reduced CRBSI. In addition, the CDC and IDSA guidelines do not mention miconazole-rifampicin-impregnated catheters. However, there are some retrospective studies showing that their use reduced CRBSI [42,50,51]. Finally, I think that the use of impregnated catheters should be considered in the following circumstances: channelling of vascular access with increased risk of CRBSI (such as the internal jugular with tracheostomy or femoral access), immunocompromised patients or patients with disorders of skin integrity.

Which technique of catheter insertion

The advantages of ultrasound-guided central venous catheterization include the identification of the position of the desired vein, the detection of anatomic variants and thrombosis within the vessel and the avoidance of inadvertent arterial puncture during the insertion.

A meta-analysis by Hind et al. [54] was performed to determine the utility of real-time two-dimensional (2-D) and Doppler ultrasound guidance for the insertion of CVCs compared with insertion based solely on anatomic landmarks. It included 18 RCTs and 1646 catheters. In the jugular sub-analysis comparing real-time 2-D ultrasound guidance and landmarks with 7 RCTs and 608 catheters, it was found that real time 2-D was associated with a lower failure rate (relative risk = 0.14, 95% CI = 0.06–0.33; $p < 0.001$) and complications (without detailing what complications) related to catheter placement (relative risk = 0.43, 95% CI = 0.22–0.87; $p = 0.02$). One RCT with 52 subclavian catheters found that real time 2-D was associated with a lower failure rate than landmarks method (relative risk = 0.14, 95% CI = 0.04–0.57; $p = 0.006$). In one RCT with 40 femoral catheters, a significantly lower failure rate was not found with real time 2-D ultrasound compared to landmark methods (relative risk = 0.29, 95% CI = 0.07–1.21; $p = 0.09$). There are studies comparing real-time 2-D with Doppler ultrasound guidance; however, the authors made an indirect comparison and found that real-time 2-D could be associated with a lower failure rate in subclavian vein procedures than Doppler ultrasound guidance (relative risk = 0.09, 95% CI = 0.02–0.38; $p < 0.001$).

After the meta-analysis, other RCTs have been published to determine the utility of real-time 2-D ultrasound guidance for the insertion of CVCs compared with insertion based solely on anatomic landmarks in jugular [55–57] and subclavian sites [58]. In one RCT by Karakitsos et al. [55] with 900 critical care patients, it was found that internal jugular vein cannulation by real-time 2-D ultrasound-guided method ($n = 450$) compared with landmarks method ($n = 450$) showed a higher successful cannulation rate (100 vs. 94.4%; $p < 0.001$), lower rate of puncture of the carotid artery (1.1 vs. 10.6%; $p < 0.001$), haematoma (0.4 vs. 8.4%; $p < 0.001$), haemothorax (0 vs. 1.7%; $p < 0.001$), pneumothorax (0 vs. 2.4%; $p < 0.001$) and CRBSI (10.4 vs. 16%; $p < 0.001$). One RCT by Milling et al. [56] was designed to compare the success rate of 201 internal jugular venous catheterizations: 60 with dynamic ultrasound (guided by real-time 2-D), 72 with static ultrasound (a quick visualization before the procedure) and 69 with anatomic landmarks. The cannulation success rates were 98%, 82% and 64% respectively, i.e. higher with dynamic and static ultrasound guidance than with the anatomic landmarks method; and dynamic ultrasound outperformed static ultrasound, but it may require more training and personnel [56]. In an observational study, Serafimidis et al. [57] compared internal jugular vein catheterization by traditional anatomic landmarks in 204 patients and by real-time 2-D ultrasound-guided method in 347 patients. The 2-D real-time ultrasound-guided technique was associated with lower catheterization failure rate (0 vs. 8.8%; $p < 0.05$), lower pneumothorax rate (0 vs. 1.0%; $p < 0.05$) and lower carotid artery puncture rate (0.3 vs. 7.8%; $p < 0.05$) [57]. In one RCT by Fragou et al. [58] with 401 subclavian vein cannulation (200 by real-time 2-D ultrasound-guided and 201 by landmarks method), the 2-D ultrasound-guided method showed higher successful cannulation rate (100 vs. 87.5%; $p < 0.05$), lower rate of puncture of the subclavian artery (0.5 vs. 5.4%; $p < 0.05$), haematoma (1.5 vs. 5.4%; $p < 0.05$), haemothorax (0 vs. 4.4%; $p < 0.05$), pneumothorax (0 vs. 4.9%; $p < 0.05$), brachial plexus injury (0 vs. 2.9%; $p < 0.05$) and phrenic nerve injury (0 vs. 1.5%; $p < 0.05$); a limitation was that the effect on the incidence of CRBSI was not recorded.

A meta-analysis by Rabindranath et al. [59], including 7 RCTs with 830 catheters (648 in jugular, 121 in femoral and 61 in subclavian vein sites), was performed to determine the utility of real-time 2-D Doppler ultrasound guidance for the insertion of haemodialysis catheters. Ultrasound guidance compared with insertion based solely on anatomic landmarks decreased the risk of catheter placement failure (7 studies and 830 catheters; relative risk = 0.12; 95% CI = 0.04–0.37), arterial punctures (6 trials and 785 catheters; relative risk = 0.22; 95% CI = 0.06–0.81) and haematoma formation (4 trials and 323 catheters; relative risk = 0.27; 95% CI = 0.08–0.88). However, there were no significant differences in the rate of pneumothorax and haemothorax.

A meta-analysis by Shiloh et al. [60] was performed to determine the utility of real-time 2-D ultrasound guidance for radial artery catheterization compared with anatomic landmarks. It included 4 RCTs with a total of 311 subjects (152 subjects by landmarks and 159 subjects by ultrasound-guided group) and ultrasound guidance was associated with an improvement in the likelihood of first-attempt success rate (27% vs. 43%; relative risk = 1.71; 95% CI = 1.25–2.32). However, data about other complications of radial artery catheterization (such as catheter-related infection and vascular damage) were not reported.

The CDC and IDSA guidelines for the prevention of intravascular catheter-related infections recommended ultrasound guidance for the placement of CVCs (if this technology is available) to reduce the number of cannulation attempts and mechanical complications. Ultrasound guidance should only be used by those fully trained in the technique (Category 1B) [24]. The CDC and IDSA guidelines do not mention the aspect of reducing CRBSI; however, one RCT found that internal jugular vein cannulation by real-time 2-D ultrasound guidance reduced the incidence of CRBSI [55]. I agree with the recommendation that ultrasound guidance should be used to place CVCs.

Conclusions

In my opinion, central internal jugular with tracheostomy and femoral venous accesses show higher risk of CRBSI and these accesses could be considered as last resort options. Rifampicin-(minocycline or miconazole) and CHSS-impregnated catheters could be considered in vascular accesses with higher risk of CRBSI (such as internal jugular with tracheostomy or femoral access) or patients with higher risk of CRBSI (immunocompromised or with disorders of skin integrity). Ultrasound guidance could help to reduce mechanical complications.

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