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REVIEW ARTICLE

Optimal Timing for Peripheral Intravenous Cannula Replacement

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Abstract:

Background:

Current literature indicates the optimal replacement time of an intravenous catheter, ranges from when “clinically indicated” (*i.e.* signs of complications such as infection, occlusion, and/or phlebitis) to three days. The time constraint is designed to prevent infection(s) and phlebitis, as well as to decrease the costs of healthcare, and the time spent by nurses, on patient care.

Aim:

To evaluate the impact of *routine* removal and re-siting of the peripheral intravenous catheter removal, compared to removal when “clinically indicated” by adults and/or pediatrics.

Search Strategy:

A search for literature was conducted *via* Cochrane Review and Web of Sciences™ Core Collection, MEDLINE, and PubMed to summarise the optimal timing for peripheral intravenous cannula replacement. One reviewer individually evaluated the trial(s), review(s), quality of the guidelines, and then, extracted the data.

Selection Criteria:

Criteria included guideline(s); randomized controlled trial(s); and reviews; all of which matched routine removal of peripheral intravenous cannulation, with re-sited when “clinically indicated”, only in patients in the hospital, partaking in intravenous medication and/or fluids. Articles of relevance to the topic, published in English, French, or Portuguese, prior to 2018, were reviewed.

Conclusion:

The effective implementation of evidence-based, guideline-based practice can decrease the catheter-related infection risk. While larger multi-site trials are required, present-day evidence asserts: the repetitive inserting of a peripheral intravenous device may raise the patient’s level of discomfort, increase the costs of healthcare, and does not decrease complications associated with peripheral intravenous devices.

Implications for Practice:

The clinically indicated intravenous catheter replacement procedure is cost-effective, compared with the recurring replacement procedure, which recurs every 72 hours; it has been suggested that healthcare institution(s) and hospital(s) have considered revising the policy, whereby intravenous catheters are replaced, if clinically indicated, only.

Keywords: Cannula replacement, Catheter-related bloodstream infection, Clinically indicated, Infection, Phlebitis, Peripheral intravenous catheter removal.

Article History

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1. INTRODUCTION

‘Intravenous Therapy’ is a common, invasive procedure amongst hospitalized patient(s), and relates to the incidence of phlebitis. Several hospitals have protocols in place, wherein replacement of IV catheters should occur between 72 to 96

hours, regardless of clinical indication. This time constraint has been designed to prevent possible complications such as infection, occlusion, and/or phlebitis. According to the Infusion Nurses Society (INS) guidelines (2016) however, there is no need to change the peripheral intravenous cannula for adult

patients, after 72 hours [1]. The INS guidelines revealed that the catheter for adult patients should be changed when clinically indicated only. For children, however, the catheter replacement is recommended only when clinically indicated.

Interventions have been created to decrease the incidence of phlebitis, including: Changing the catheter material(s) [2], the use of heparinized catheters [3] and innovative techniques for securing the catheters [4].

Registered Nurses are authorized to insert peripheral intravenous cannulation for patients who need intravenous fluid(s) and/or treatment(s). Accordingly, from the time of insertion to the time of the catheter's removal, Registered Nurses have an essential role in patient care and frequently check the catheter to limit and/or prevent complication(s).

This study aimed to evaluate the impact(s) of peripheral intravenous catheters removal and routinely re-siting the catheter, compared with removal when clinically indicated, by pediatrics and adult patients.

2. METHODS

2.1. Selection Criteria

All randomized controlled trials, guidelines, and systematic reviews, examining the routine removal of peripheral intravenous and removal only when clinically indicated were included; cross-over trials were not included in this review. However, research involving patients' needing peripheral intravenous cannulation to be on site, for at least 72 hours, for the administration of the intravenous therapy, was included as well. These involved patients in a healthcare setting(s) such as clinics, hospitals, and/or nursing homes. However, any study comprised of patients receiving nutrition and/or parenteral fluid(s) was excluded.

Any duration of routine replacement or clinically indicated replacement were involved; cannulation or catheters formed from any brand of material such as metal or plastic; coated or non-coated with any brand of the treatment(s), such as antibiotic or anticoagulant; or covered by any dressing such as gauze or transparent occlusive were included.

2.2. Approach

A randomized controlled trial is defined as "a study design which assigns participants (randomly) to a control group or an experimental group. As the study is conducted, the only expected difference between the control and experimental groups in a Randomized Controlled Trial (RCT) is the outcome variable being studied," [5]. A systematic review "is a review of a clearly formulated question that uses systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyze data from the studies that are included in the review," [6].

Finally, The Institute of Medicine (IOM) [7] defined clinical practice guidelines as "statements that include recommendations intended to optimize patient care that is

informed by a systematic review of evidence and an assessment of the benefits and harms of alternative care options."

The references were employed in this systematic review, whereby several references are assessed critically to provide evidence on the topic. The results of retrieving the references were explained and summarised in the tables to provide a clear picture of the issue. Based on such results, it was desirable to make judgments and suggestions [8].

2.3. Searching Methods

A literature search was conducted between January and February 2018 using the Cochrane Review Database and Web of Sciences™, MEDLINE, and PubMed, to review the optimal timing for replacement of peripheral intravenous cannulation. The search terms were "cannula replacement," "clinically indicated," "catheter-related bloodstream infection," "infection" and "phlebitis."

All the articles for relevance to the topic published in the English, French or Portuguese languages before 2018 were reviewed. Looking for the best evidence, the search was conducted for the last ten years from 2008 to 2018. However, we found some important articles in the literature prior to 2008; thus, it was included in the inclusion criteria. However, the first author individually assessed all the clinical trials, systematic reviews and guidelines quality to extract the data.

2.4. Ethical Consideration

According to the Human Subjects Protection guidelines, this review was considered IRB-exempt, since all the studies included in this review were published, available online, and individual patients were not identified. The study was based on ethical guidelines for conducting studies. All the sources included in the study are appropriately cited and referenced.

3. RESULTS

3.1. Study Identification and Selection

Twenty-one studies of optimal timing for peripheral IV cannula replacement in adults and paediatrics were identified. These studies included eight randomised, controlled trials, five non-randomized trials, and eight systematic reviews and guidelines. Table 1 summarizes the studies regarding the optimal timing for peripheral IV cannula replacement in adults, while Table 2 summarizes the studies regarding the optimal timing for the replacement of peripheral intravenous cannula in paediatrics.

3.2. Peripheral Intravenous Cannula Replacement in Adults

Despite the fact, most hospitals' policies indicated routine changes of intravenous catheters every 3 to 4 days, there is no conclusive evidence to support the benefit of that practice [9 - 15]. One randomised, controlled trial found that the clinically indicated replacement strategy is more cost-effective, compared with the routine replacement strategy [16]. In addition, another randomized, controlled trial found no difference in occlusion and phlebitis rates amongst patients for wh-

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Table 1. Summary of optimal timing for peripheral intravenous cannula replacement in adults' studies.

Study Title	Year	Method	Findings
[9] Routine Replacement or Clinically Indicated Replacement of Peripheral Intravenous Catheters	2018	Randomized controlled trial	The outcomes of this study show that the catheters can remain on the site to 96 hours if they do not have complications after 72 hours. Therefore, patients experience less pain and nurses' time and equipment will be saved.
[10] Development of Evidence-based Nursing Practice Guidelines for Peripheral Intravenous Catheter Management in Hospitalized Children and Adult.	2017	Guideline	Peripheral Intravenous Catheter Catheters should be re-placed only in cases of complications.
[11] Complications related to the use of peripheral venous catheters: A randomized clinical trial	2016	Randomized controlled trial	The catheter in the experimental group was inserted without complications for an average of 3.73 (± 2.25) and a maximum of 10 days while the catheter of the control group was preserved for 3.28 (± 1.66) and a maximum of seven days.
[12] Clinically-indicated replacement <i>versus</i> routine replacement of peripheral venous catheters	2015	Systematic Review	The review found no evidence to support changing catheters every 72 to 96 hours. Consequently, healthcare organisations may consider changing to a policy whereby catheters are changed only if clinically indicated. This would provide significant cost savings and would spare patients the unnecessary pain of routine re-sites in the absence of clinical indications. To minimise peripheral catheter-related complications, the insertion site should be inspected at each shift change and the catheter removed if signs of inflammation, infiltration, or blockage are present.
[16] Cost-Effectiveness Analysis of Clinically Indicated <i>versus</i> Routine Replacement of Peripheral Intravenous Catheters	2014	Randomized controlled trial	The clinically indicated catheter replacement strategy is cost saving compared with routine replacement. It is recommended that healthcare organisations consider changing to a policy whereby catheters are changed only if clinically indicated.
[13] Optimal timing for peripheral IV replacement	2013	Equivalence trial	It is hospital policy to replace the catheter every 96 hours.
[19] Routine <i>versus</i> clinically indicated replacement of peripheral intravenous catheters: a randomised controlled equivalence trial	2012	Multicenter, randomised, non-blinded equivalence trial	Peripheral intravenous catheters can be removed as clinically indicated; this policy will avoid millions of catheter insertions, associated discomfort, and substantial costs in both equipment and staff workload.
[14] Guidelines for the prevention of intravascular catheter-related infections.	2011	Guidelines	It is not necessary to replace peripheral IV catheters in adults more than every 72 to 96 hours.
[15] Clinically-indicated replacement <i>versus</i> routine replacement of peripheral venous catheters	2010	Systematic Review	The review found no conclusive evidence of benefit in changing catheters every 72 to 96 hours. Consequently, healthcare organisations may consider changing to a policy whereby catheters are changed only if clinically indicated. This would provide significant cost savings and would also be welcomed by patients, who would be spared the unnecessary pain of routine re-sites in the absence of clinical indications.
[17] Routine Replacement <i>versus</i> Clinical Monitoring of Peripheral Intravenous Catheters in a Regional Hospital in the Home Program A Randomized Controlled Trial.	2009	Randomized controlled trial	This randomised, controlled trial involving 316 patients in the home setting found no difference in the rate of phlebitis and/or occlusion among patients for whom a peripheral intravenous catheter was routinely re-sited at 72-96 hours and those for whom it was replaced only on clinical indication.
[18] Routine care of peripheral intravenous catheters <i>versus</i> clinically indicated replacement: randomised controlled trial	2008	Randomized controlled trial	Replacing peripheral intravenous catheters when clinically indicated has no effect on the incidence of failure, based on a composite measure of phlebitis or infiltration.
[20] Intravenous peripheral catheter dwell times: randomised controlled trial of hospital in-patients.	2005	Randomized controlled trial	Re-siting peripheral venous cannulas when clinically indicated compared with changing them routinely every three days does not lead to more complications and reduces costs.
[21] Optimal Frequency of Changing Intravenous Administration Sets: Is It Safe to Prolong Use Beyond 72 Hours?	2001	A prospective, nonrandomized study	In patients at low risk for infection from infusion- or catheter-related infection who are not receiving total parenteral nutrition, blood transfusions, or interleukin-2, delaying the replacement of IV tubing up to 7 days may be safe, as well as cost-effective.
[22] Safety of prolonging peripheral cannula and IV tubing use from 72 hours to 96 hours.	1998	A prospective, nonrandomized study	Phlebitis rate for our peripheral intravenous catheters at 96 hours was not significantly different from that at 72 hours. If intravenous cannulas and lines were prolonged to 96 hours, a potential cost saving of \$61,200 per year could be realised.

Table 2. Summary of optimal timing for peripheral intravenous cannula replacement in paediatrics studies.

Study Title	Year	Method	Findings
[26] Paediatric vascular access	2015	Review	The choice of a long-term vascular access device in children is guided by duration and frequency of therapy, the infusate's properties, and the condition and preferences of the patient and caregivers.
[25] Routine <i>versus</i> clinically indicated replacement of intravenous catheter complications in children: a randomized clinical trial	2015	Randomized clinical trial	The findings of this study showed superior clinical indication method compared with routine catheter replacement.
[12] Clinically-indicated replacement <i>versus</i> routine replacement of peripheral venous catheters.	2015	Systematic Review	The authors found no evidence to support changing catheters every 72 to 96 h. Consequently, they suggested that healthcare organizations consider a policy in which catheters are changed only if clinically indicated.
[23] Peripheral intravenous (IV) device management.	2014	Guidelines	Re-cannulation should be avoided where possible, as this will cause the child and family further distress. There is no limit to the length of time that a cannula may remain in situ and with appropriate care, several days may be possible. Cannulas only need to be replaced when there is accidental dislodgement, occlusion, Phlebitis and infection.
[19] Routine <i>versus</i> clinically indicated replacement of peripheral intravenous catheters: a randomised controlled equivalence trial.	2012	Randomized controlled equivalence trial	Peripheral intravenous catheters can be removed as clinically indicated; this policy will avoid millions of catheter insertions, associated discomfort, and substantial costs in both equipment and staff workload.
[14] Guidelines for the prevention of intravascular catheter-related infections	2011	Guidelines	Replace peripheral catheters in children only when clinically indicated.
[24] Routine resite of peripheral intravenous devices every three days did not reduce complications compared with clinically indicated resite: a randomised controlled trial	2010	Randomized controlled trial	There is growing evidence to support the extended use of peripheral IVDs with removal only on clinical indication.
[27] Healthcare Infection Control Practices Advisory Committee. Guidelines for the prevention of intravascular catheter-related infections.	2002	Guidelines	The risk for phlebitis in children has not increased with the duration of catheterisation.
[28] Peripheral intravenous catheter complications in critically ill children: a prospective study.	1992	Prospective study	Replacing catheters in critically ill children every 72 hours would not decrease phlebitis, bacterial colonisation, or catheter-induced sepsis and could increase extravasation risk. Catheters can be safely maintained with adequate monitoring for up to 144 hours in critically ill children.
[29] Percutaneous central venous catheterization in a pediatric intensive care unit: a survival analysis of complications	1989	Prospective study	No relation was found between duration of catheterisation and the daily probability of infection.
[30] Infectious complications during peripheral intravenous therapy with Teflon catheters: a prospective study.	1987	Prospective study	In children in a general pediatric ward, the risk of catheter colonisation and subsequent sepsis should not be used as reasons for routinely removing complication-free peripheral Teflon catheters at 72 hours.

om a peripheral intravenous cannula was replaced routinely 3-4 days and those for whom it was re-sited only when clinically needed [17]. Also, another randomized, controlled trial found that re-siting peripheral intravenous catheters when clinically indicated has no impact on the incidence of failure, based on a composite measure of phlebitis or infiltration [18]. Peripheral intravenous cannulas can be removed when clinically indicated. This shift in practice will minimize many catheter insertions, the associated discomfort, and extensive costs in both equipment and staff workload; also it would spare patients the unnecessary pain-related to routine re-sites [12, 16, 19 - 21]. In addition, clinically indicated intravenous cannula replacement is harmless practice especially for patients who are at low risk for infection and who are not receiving total parenteral nutrition, blood transfusions, or interleukin [12, 14, 22].

3.3. Peripheral Intravenous Cannula Replacement in Pediatrics

There is developing evidence to recommend the pro-

longed use of peripheral intravenous catheters and with removal only when clinically indicated for pediatric patients [12, 14, 19, 23, 24]. Re-sited the cannula should be avoided when possible, as this will affect and distress the child and parents [23]. One study showed that intravenous cannula could be maintained safely with adequate monitoring for up to six days in critically ill children [24]. Also, one randomized clinical trial showed superior clinical indication method, compared with routine catheter replacement [25]. One study suggested that intravenous catheters indicated replacement when there is accidental dislodgement, phlebitis, occlusion and infection [23].

There are factors that also would interfere with catheter replacement among pediatric patients. This includes the duration and frequency of therapy, the infusate's properties, the condition and patient preferences [26]. Many studies showed that replacing catheters in children every three days would not decrease phlebitis, bacterial colonisation, or catheter-induced sepsis and could increase extravasation risk [27 - 30].

4. DISCUSSION

Intravenous cannulation is one of the most frequent invasive procedures hospitalized patient would have. The optimal timing for peripheral intravenous cannula replacement among adults and pediatrics patients is still an argumentative issue. A growing number of studies supported the replacement decision of intravenous catheters when it is clinically indicated. However, this study aimed to evaluate the impact of peripheral intravenous catheter removal and re-siting the catheter routinely, compared with removal when clinically needed, among pediatrics and adults.

Moreover, there is no conclusive evidence to support the benefit of a routine change of intravenous catheters, every 72 to 96 hours. Though it is recommended to inspect the IV catheter insertion site after every 12 hours to minimise peripheral catheter-related complications, and to replace if signs of inflammation, infiltration, or blockage are present. The duration and frequency of therapy, the infusate's properties, and the condition and preferences of the patient can be used as conditions to decide on the proper time for intravenous catheter replacement.

The studies showed that clinically indicated intravenous replacement method is superior as it minimizes several catheter insertions, discomfort associated with catheter insertion, and extensive costs in both equipment and staff workload. Moreover, it would spare patients the unnecessary pain of routine replacements, especially for pediatric patients. In addition, many randomized, clinical trials found no difference in the rate of phlebitis and/or occlusion among patients for whom a peripheral intravenous catheter was routinely re-sited at 72-96 hours and those for whom it was replaced, only as clinically indicated.

CONCLUSION

Effective implementation of these evidence-based guidelines practice can decrease the catheter-related infection risk. While larger multisite trials are needed, evidence up to the present time recommends that repetitive insertion of peripheral intravenous devices may make patient upset, discomfort and increase healthcare costs as well as it does not decrease peripheral intravenous devices complications. The clinically indicated intravenous catheter replacement procedure is cost-effective compared with replacement after every 72 hours. It is suggested that hospitals and healthcare institutions consider revising the policy whereby intravenous catheters are replaced if clinically indicated only.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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REFERENCES

- [1] Infusion Nurses Society. Infusion therapy standards of practice. J Infus Nurs 2016.
- [2] Cornely OA, Bethe U, Pauls R, Waldschmidt D. Peripheral Teflon catheters: Factors determining incidence of phlebitis and duration of cannulation. Infect Control Hosp Epidemiol 2002; 23(5): 249-53. [http://dx.doi.org/10.1086/502044] [PMID: 12026149]
- [3] Shah PS, Ng E, Sinha AK. Heparin for prolonging peripheral intravenous catheter use in neonates. Cochrane Database Syst Rev 2005; (4): CD002774. [http://dx.doi.org/10.1002/14651858.CD002774.pub2] [PMID: 16235300]
- [4] Callaghan S, Copnell B, Johnston L. Comparison of two methods of peripheral intravenous cannula securement in the pediatric setting. J Infus Nurs 2002; 25(4): 256-64. [http://dx.doi.org/10.1097/00129804-200207000-00009] [PMID: 12131508]
- [5] Himmelfarb Health Sciences Library (The George Washington University). Study Design 101: Randomized Controlled Trial 2011.
- [6] Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Ann Intern Med 2009; 151(4): 264-269, W64. [http://dx.doi.org/10.7326/0003-4819-151-4-200908180-00135] [PMID: 19622511]
- [7] Institute of Medicine (IOM). About systematic evidence reviews and clinical practice guidelines. Natl Hear Lung, Blood Inst 2016.
- [8] Brink H, Van der Walt C, Van Rensburg G. Fundamentals of Research Methodology for Health Care Professionals. Juta and Company Ltd.; 2006. https://books.google.com/books?hl=en&lr=&id=YZnPYoA4Jk0C&oi=fnd&pg=PA1&dq=Bri nk+H, +Van+WC, +Van+RG. +In:+Br ink+H, +Van +der +Walt+C, +Van+ Rensburg+G, +editors. +Fundamentals+ of +Research+ Methodology+ for+ Health+ Care +Professionals &ots=9V BjcNHzS &sig=rA- jwFU4-G4JPLFP Accessed May 18, 2018.
- [9] Foumani S, Paryadi E, Khanghah A LE. Routine replacement or clinically indicated replacement of peripheral intravenous catheters. J Pharm Res Int 2018; 23(3): 1-10. [http://dx.doi.org/10.9734/JPRI/2018/38767]
- [10] Kim Y, Lee S, Park H, Sohng K, Kim S. Development of evidence-based nursing practice guidelines for peripheral intravenous catheter management in hospitalized children and adult. Int J Stud Nurs 2017; 3(1): 82. [http://dx.doi.org/10.20849/ijns.v3i1.309]
- [11] Danski MTR, Johann DA, Vayego SA, et al. Complicações relacionadas ao uso do cateter venoso periférico: Ensaio clínico randomizado. Acta Paul Enferm 2016; 29(1): 84-92. [http://dx.doi.org/10.1590/1982-0194201600012]
- [12] Webster J, Osborne S, Rickard CM, New K. Clinically-indicated replacement versus routine replacement of peripheral venous catheters. Cochrane Database Syst Rev 2015; (8): CD007798. [Review]. [http://dx.doi.org/10.1002/14651858.CD007798.pub4] [PMID: 26272489]
- [13] Brown D, Rowland K. PURLs: Optimal timing for peripheral IV replacement? J Fam Pract 2013; 62(4): 200-2. [PMID: 23570032]
- [14] O'Grady NP, Alexander M, Burns LA, et al. Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis 2011; 52(9): e162-93. [http://dx.doi.org/10.1093/cid/cir257] [PMID: 21460264]
- [15] Webster J, Osborne S, Rickard C, Hall J. Clinically-indicated replacement versus routine replacement of peripheral venous catheters. Cochrane Database of Systematic Reviews. Chichester, UK: John Wiley & Sons, Ltd 2010. [http://dx.doi.org/10.1002/14651858.CD007798.pub2]
- [16] Tuffaha HW, Rickard CM, Webster J, et al. Cost-effectiveness analysis of clinically indicated versus routine replacement of peripheral intravenous catheters. Appl Health Econ Health Policy 2014; 12(1): 51-8. [http://dx.doi.org/10.1007/s40258-013-0077-2] [PMID: 24408785]
- [17] Van Donk P, Rickard CM, McGrail MR, Doolan G. Routine replacement versus clinical monitoring of peripheral intravenous catheters in a regional hospital in the home program: A randomized

- controlled trial. *Infect Control Hosp Epidemiol* 2009; 30(9): 915-7. [http://dx.doi.org/10.1086/599776] [PMID: 19637959]
- [18] Webster J, Clarke S, Paterson D, *et al.* Routine care of peripheral intravenous catheters *versus* clinically indicated replacement: Randomised controlled trial. *BMJ* 2008; 337: a339. [http://dx.doi.org/10.1136/bmj.a339] [PMID: 18614482]
- [19] Rickard CM, Webster J, Wallis MC, *et al.* Routine *versus* clinically indicated replacement of peripheral intravenous catheters: A randomised controlled equivalence trial. *Lancet* 2012; 380(9847): 1066-74. [http://dx.doi.org/10.1016/S0140-6736(12)61082-4] [PMID: 22998716]
- [20] Webster J, Lloyd S, Hopkins T, Osborne S, Yaxley M. Intravenous peripheral catheter dwell times: Randomised controlled trial of hospital in-patients. *Fac Heal Inst Heal Biomed Innov* 2005. Available at: <http://eprints.qut.edu.au/2249/> Accessed December 4, 2018.
- [21] Raad I, Hanna HA, Awad A, *et al.* Optimal frequency of changing intravenous administration sets: Is it safe to prolong use beyond 72 hours? *Infect Control Hosp Epidemiol* 2001; 22(3): 136-9. [http://dx.doi.org/10.1086/501879] [PMID: 11310690]
- [22] Lai KK. Safety of prolonging peripheral cannula and i.v. tubing use from 72 hours to 96 hours. *Am J Infect Control* 1998; 26(1): 66-70. [http://dx.doi.org/10.1016/S0196-6553(98)70063-X] [PMID: 9503115]
- [23] Portal MR. Peripheral intravenous (IV) device management. *R Child Hosp Melb* 2014.
- [24] Rickard CM, McCann D, Munnings J, McGrail MR. Routine resite of peripheral intravenous devices every 3 days did not reduce complications compared with clinically indicated resite: A randomised controlled trial. *BMC Med* 2010; 8(1): 53. [http://dx.doi.org/10.1186/1741-7015-8-53] [PMID: 20831782]
- [25] Hosseinzadeh E, Khakshour A, Shakeri A, Ahmadi A, Lashkardoost H. Routine *versus* clinically indicated replacement of intravenous catheter complications in children: A randomized clinical trial. *J North Khorasan* 2015; 6(2)
- [26] Scott-Warren V, Morley R. Paediatric vascular access. *BJA Educ* 2015; 15(4): 199-206. [http://dx.doi.org/10.1093/bjaceaccp/mku050]
- [27] O'Grady NP, Alexander M, Dellinger EP, *et al.* Guidelines for the prevention of intravascular catheter-related infections. *Infect Control Hosp Epidemiol* 2002; 23(12): 759-69. [http://dx.doi.org/10.1017/S0195941700080577] [PMID: 12517020]
- [28] Garland JS, Dunne WM Jr, Havens P, *et al.* Peripheral intravenous catheter complications in critically ill children: A prospective study. *Pediatrics* 1992; 89(6 Pt 2): 1145-50. <http://pediatrics.aappublications.org/content/89/6/1145.short> [PMID: 1594367]
- [29] Stenzel JP, Green TP, Fuhrman BP, Carlson PE, Marchessault RP. Percutaneous central venous catheterization in a pediatric intensive care unit: A survival analysis of complications. *Crit Care Med* 1989; 17(10): 984-8. [http://dx.doi.org/10.1097/00003246-198910000-00003] [PMID: 2791583]
- [30] Garland JS, Nelson DB, Cheah TE, Hennes HH, Johnson TM. Infectious complications during peripheral intravenous therapy with Teflon catheters: A prospective study. *Pediatr Infect Dis J* 1987; 6(10): 918-21. [http://dx.doi.org/10.1097/00006454-198710000-00012] [PMID: 3696824]