

Comparing the Success Rate of Radial Artery Cannulation under Ultrasound Guidance and Palpation Technique in Adults

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Background: Previous studies have shown ultrasound guidance (USG) for arterial cannulation being advantageous compared to palpation technique, but little is known about its performance by novices.

Objective: This study was to compare the utility of USG radial artery cannulation with palpation technique in terms of success rate, real-time to placement, number of attempts and complications.

Material and Method: After IRB approval, a randomized prospective study was performed November 2009-October 2010. Ten third-year residents, having performed USG vascular catheterization as yet less than 3 times, were coached on the pork-phantom during a workshop for real time ultrasound-guided vascular access. For the study patients were randomized to US-guided technique (US-group) and palpation (P-group); ten patients for each resident.

Results: One hundred adult patients undergoing neurosurgery were enrolled. There were no statistically significant differences between US-group vs. P-group in success rate (78% vs. 82%; $p = 0.62$), time to success (60 (12.8, 547.0) vs. 52 (6.9, 639.0) sec; $p = 0.22$), and number of attempts (1 (1, 4) vs. 1 (1, 3); $p = 0.79$). Most common complication was puncture hematoma (US-group 26% vs. P-group 24%; $p = 0.82$). Success was defined as no change in catheterization site, performer and technique.

Conclusion: Regarding success rate, attended time, or number of attempts for radial arterial cannulation, we did not find any benefit of ultrasound guidance compared to palpation technique. Our findings were not in accordance to other trials. However, we have to consider operators in our study being in experienced in ultrasound-guided procedures but not in palpation techniques.

Keywords: Radial artery, Cannulation technique, Ultrasound, Palpation, Experience

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Radial artery cannulation is a well-established approach for invasive blood pressure monitoring and blood sampling to perform blood gas analyses in major surgery and patients in critical condition⁽¹⁾. After decades of experience in radial artery cannulation, landmark-guided palpation is considered the first-line technique to identify the optimal site of puncture⁽²⁾. However, in certain difficult conditions such as obesity, edematous or hypotensive patients, as well as small infants, there may be limitations for landmark-guided palpation increasing the risk of complications. These complications include: hematoma; infection;

thrombosis, ischemia and complex pain syndrome^(1,3-6). Some studies have suggested advantages of ultrasound-guided (USG) techniques^(7,8). However, the benefit of ultrasound for radial artery cannulation is not finalized yet, and data from randomized studies as well as meta-analyses are conflicting⁽⁸⁻¹⁰⁾. Peters et al reported that among experienced cardiologists the use of ultrasound for radial cannulation had no impact on insertion times, puncture problems, or the number of attempts when compared with direct palpation⁽¹¹⁾.

The objective of this study was to compare the utility of USG radial artery cannulation with landmark-guided palpation technique in terms of success rate, real-time to placement, number of attempts and complications. At Siriraj Hospital ultrasound-guided technique had been mainly used for peripheral nerve blockade and central venous approach rather than arterial cannulation. Hence our study also aimed

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to the usefulness of ultrasound technique for radial artery catheterization.

Material and Method

After Institutional Review Board approval (IRB No. 495/2552), a randomized prospective study was performed between November 2009 and October 2010 in neurosurgical patients. Ten third-year residents, having performed USG vascular catheterization less than 3 times, but cannulation with palpation technique more than 50 times were coached on the pork-phantom during a workshop for real time ultrasound-guided vascular access. This workshop has been for the preliminary training and familiarization with the ultrasound technique before applying it for radial artery catheterization. The coaching anesthesiologist had performed USG procedures more than 200 times with more than 3 years' experience.

Using computer generated block randomization (mixed block size) each resident was assigned to 10 patients, 5 of them being allocated to US-guided technique (U-group) and 5 to palpation technique (P-group) (5 each). Following this schedule each operator had 2x5 patients with alternative puncture approach in a randomized sequence.

Inclusion criteria: patients ≥ 18 years old with indication for radial artery cannulation. Excluded were pregnant women, patients who had negative modified Allen's test and patients with severe vascular morbidity such as limb ischemia from multiple insertion attempts and air emboli.

Patients were evaluated by the anesthetic team the evening before surgery. The following data were recorded: sex; age; weight; height; blood pressure; heart rate; underlying disease and planned operation; relevant co-morbidity; carpal tunnel syndrome, history of smoking, history of allergies and type of surgery to be conducted. Patients' informed consent included radial artery cannulation and the acceptance to participate in the study. Every patient had to pass the modified Allen's test.

The patients were followed by a 24 hours follow-up period observing complications such as hematoma, infection, retained catheter, radial nerve damage, arterial thrombosis/ischemia and carpal tunnel syndrome.

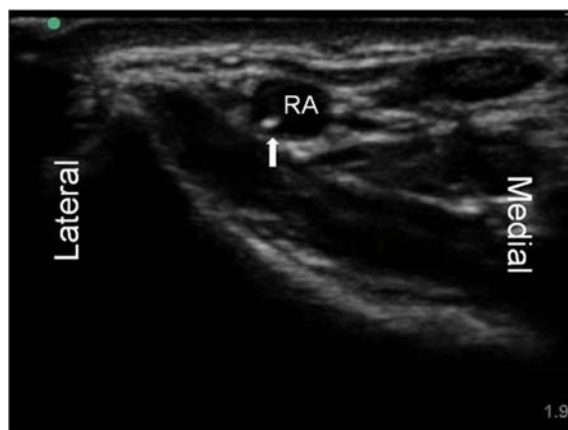
Ultrasound transducer 6-13 MHz (Micromaxx, SonoSite Inc.; US) was applied as demonstrated in Fig. 1 for real-time ultrasound guidance technique, identifying the radial artery with the short axis, out-of-plane needle approach (Fig. 1 and 2) and the long axis

approach, radial artery catheter confirmation (Fig. 3). Punctures were performed under strict aseptic conditions, in dorsiflexion position and insertion of a 20-gauge Jelco® IV catheter (Smiths medical, USA). Whereas palpation technique was applied by landmark-guided identification of radial artery pulse.

Success rate was defined as no changes of anatomic approach, operator, technique and time needed to be less than 10 minutes. Time began with skin puncture and concluded with complete and adequate catheter insertion. The number of attempts was counted at each skin puncture or needle withdrawal from skin.



Fig. 1 Short axis, Out-of-plane needle approach.



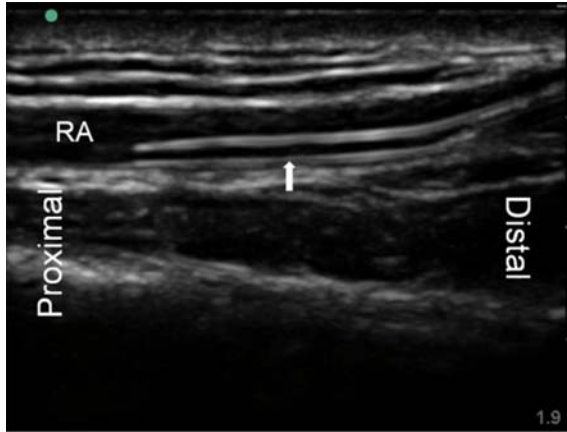
RA = radial artery; Arrow = needle tip

Fig. 2 Ultrasound image of radial artery in the short axis, out-of-plane needle approach.

Statistics

We used nQuery program and SPSS program. Sample size was calculated based on the prospective, randomized, comparative study of Levin and co-workers in 69 patients with radial cannulation and an initial success rate of 62% and 34% for either US-guided or landmark-guided palpation approach⁽¹²⁾. The sample size needed for our study was 50 patients per group by N-Query software calculation.

Demographics data were analyzed by t-test, Chi-square test. Presentation and statistical evaluation of success rate, time to success, number of attempts and complications were performed by plot histogram, mean, SD, Cross table, Chi-square, Fisher's exact test as necessary and Mann-Whitney tests. Differences were considered significant with $p < 0.05$.



RA = radial artery; Arrow = catheter

Fig. 3 Ultrasound image of radial artery in the long axis, radial artery catheter confirmation.

Results

One hundreds patients were enrolled with 50 patients assigned to each group, being either P-group or US-guided group. Regarding patients characteristics there were no significant differences between the two groups as shown in Table 1.

Table 2 shows the performance characteristics within the two groups. There were no significant differences between the groups; success rate, total time to success, number of attempts, and number of catheter cannulation were similar between the groups. Successful radial artery cannulation was placed insignificant difference on the first attempt (US-group vs. P-group: 69% vs. 65%; $p = 0.31$) but time was significantly shorter in P-group (US-group vs. P-group: 52.6 ± 33.3 vs. 36.1 ± 24.7 ; $p = 0.043$). The most common complication was hematoma (US-group vs. P-group: 26% vs. 24%; $p = 0.82$), but without effect of the respective cannulation technique. In patients with 'non-success', a change of catheterization site or operator had to performed to achieve arterial access. There were no statistically significant differences on respective technique between US-guided vs. group P-group in non-success patients.

Discussion

All patients were successfully provided with an arterial cannulation, but not all with the first attempt and not all at the scheduled anatomic site, which, however, was not affected by the respective cannulation technique (Table 2). Regarding the success rate, attended time, and number of attempts for radial artery cannulation, ultrasound-guided technique did not facilitate the advantages compared to palpation technique in adult patients. Our findings are in

Table 1. Characteristics of patients with radial artery cannulation

Parameter	Technique		
	Ultrasound group (n = 50)	Palpation group (n = 50)	p-value
Age (years)	51.0 \pm 15.3	50.4 \pm 15.1	0.860
BMI	23.4 \pm 3.7	24.4 \pm 3.7	0.199
Sex (male: female)	20:30	19:31	0.838
ASA physical status, n (%)			0.480
1	4 (8)	3 (6)	
2	36 (72)	41 (82)	
3	10 (20)	6 (12)	

* ASA = American society of anesthesiologists

Table 2. Success and difficulties during radial artery cannulation

Parameter	Technique		
	Ultrasound group (n = 50)	Palpation group (n = 50)	p-value
Successful cannulation, n (%)	39/50 (78.0)	41/50 (82.0)	0.617
Time to first success ¹ (sec) (mean ± SD)	52.6±33.3	36.1±24.7	0.043*
Time to success ² : median (range)	60 (12.8, 547.0)	52 (6.9, 639.0)	0.216
Number of attempts: median (range)	1 (1,4)	1 (1,3)	0.792
No. of catheter to success ³ : median (range)	1 (1,9)	1 (1,4)	0.418
Hematoma, n (%)	13/50 (26.0)	12/50 (24.0)	0.817
Failure	11/50	9/50	
Another site (change in hand), n (%)	8/11 (72.7)	9/9 (100)	0.218
Another performer, n (%)	4/11 (36.4)	2/9 (22.2)	0.642
Another technique, n (%)	6/11 (54.5)	1/9 (11.1)	0.070

¹ Time to first success was defined as the success on the first arterial puncture

² Time to success was defined as time from skin puncture till successful radial artery cannulation

³ Change in catheterization site

* $p < 0.05$

accordance to some but not all other trials^(8,13). Seto et al in their multicenter trial found ultrasound to be superior to direct palpation⁽¹⁴⁾, whereas Peters and co-workers in their single center randomized trial did not find such benefit⁽¹¹⁾. The recent meta analysis of Gao et al suggests advantages for ultrasound, but also warn of premature conclusions, as the recent literature includes a large amount of potential bias and heterogeneity of data. They recommend future studies to establish the role of ultrasound and identify its benefit as well as its risks⁽⁹⁾.

Some authors have emphasized the issue of a different learning curve for ultrasound and palpation technique respectively, with advantages for ultrasound regarding easy and fast learning^(15,16). In a recent study of Roberts and Manur a cardiologist with little experience in ultrasound-guided radial access successfully performed radial cannulation in 50 consecutive cases within 35-50 seconds without any complications or problems⁽¹⁷⁾.

Thailand is a so called emerging country with limitations regarding funding and equipment, for both medical research and clinical practice. As a consequence new knowledge cannot always be adequately applied. Many hospitals don't have an ultrasound machine. Therefore, mainly palpation technique to insert arterial lines is taught and performed. Therefore the first choice of radial arterial cannulation for the 'normal' adult patient is the palpation technique,

whereas USG approach is reserved for difficult cases, such as extreme obesity and small infants.

An essential limitation of this study is the operators' experience. Comparing our data to the recent literature we have to consider that the operators in our study were in experienced in ultrasound application but experienced in palpation technique. The results of our study are different to the conclusions drawn from the large meta-analysis from Tang et al because of the inexperience of operators performing ultrasound-guided cannulation⁽¹⁸⁾. The learning curve during training of ultrasound-guided radial artery cannulation is steep. To gain assurance in performance the recent guidelines of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists suggest a minimum of 10 procedures performed under the supervision of an experienced practitioner⁽¹⁹⁾.

Although ultrasound may identify the location and patency of arteries suitable for vascular access, the guidelines do not generally recommend routine real-time ultrasound use for arterial cannulation. The technique, however, may be useful an alternative in difficult situations such as hypotension, low cardiac output, barely or not at all palpable pulse, the presence of arterial spasm or hematoma and excessive limb circumference⁽¹⁹⁾. Currently the landmark-guided technique is considered as first choice for the trainee. Future studies should compare different cannulation techniques performed by operators with identical

educational level; both experienced and inexperienced.

Conclusion

Anesthesiologists inexperienced with ultrasound technique performed radial artery cannulation with a similar success rate as experienced colleagues using palpation technique. Ultrasound-guided technique did not facilitate the advantages compared to palpation technique in adult patients.

What is already known on this topic?

The first-attempt success rate during arterial cannulation is higher when using ultrasound-guided approach compared with palpation alone. Ultrasound can facilitate access to all these arteries but is particularly useful in patients with obesity, altered anatomy, low perfusion, nonpulsatile blood flow, and previously unsuccessful cannulation attempts using a landmark-guided approach.

What this study adds?

Anesthesiologists inexperienced with ultrasound technique performed radial artery cannulation with a similar success rate as experienced colleagues using palpation technique.

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Potential conflicts of interest

None.

References

1. Scheer B, Perel A, Pfeiffer UJ. Clinical review: complications and risk factors of peripheral arterial catheters used for haemodynamic monitoring in anaesthesia and intensive care medicine. *Crit Care* 2002; 6: 199-204.
2. Brzezinski M, Luisetti T, London MJ. Radial artery cannulation: a comprehensive review of recent anatomic and physiologic investigations. *Anesth Analg* 2009; 109: 1763-81.
3. Wilkins RG. Radial artery cannulation and ischaemic damage: a review. *Anaesthesia* 1985; 40: 896-9.
4. Lazaro RP. Complex regional pain syndrome and acute carpal tunnel syndrome following radial artery cannulation: a neurological perspective and review of the literature. *Medicine (Baltimore)* 2015; 94: e422.
5. Slawin J, Kubler P, Szczepanski A, Piatek J, Stepkowski M, Reczuch K. Radial artery occlusion after percutaneous coronary interventions-an underestimated issue. *Postepy Kardiol Interwencyjnej* 2013; 9: 353-61.
6. Araki T, Itaya H, Yamamoto M. Acute compartment syndrome of the forearm that occurred after transradial intervention and was not caused by bleeding or hematoma formation. *Catheter Cardiovasc Interv* 2010; 75: 362-5.
7. Shiloh AL, Savel RH, Paulin LM, Eisen LA. Ultrasound-guided catheterization of the radial artery: a systematic review and meta-analysis of randomized controlled trials. *Chest* 2011; 139: 524-9.
8. Ueda K, Bayman EO, Johnson C, Odum NJ, Lee JJ. A randomised controlled trial of radial artery cannulation guided by Doppler vs. palpation vs. ultrasound. *Anaesthesia* 2015; 70: 1039-44.
9. Gao YB, Yan JH, Gao FQ, Pan L, Wang XZ, Lv CJ. Effects of ultrasound-guided radial artery catheterization: an updated meta-analysis. *Am J Emerg Med* 2015; 33: 50-5.
10. Gu WJ, Tie HT, Liu JC, Zeng XT. Efficacy of ultrasound-guided radial artery catheterization: a systematic review and meta-analysis of randomized controlled trials. *Crit Care* 2014; 18: R93.
11. Peters C, Schwarz SK, Yarnold CH, Kojic K, Kojic S, Head SJ. Ultrasound guidance versus direct palpation for radial artery catheterization by expert operators: a randomized trial among Canadian cardiac anesthesiologists. *Can J Anaesth* 2015; 62: 1161-8.
12. Levin PD, Sheinin O, Gozal Y. Use of ultrasound guidance in the insertion of radial artery catheters. *Crit Care Med* 2003; 31: 481-4.
13. Hansen MA, Juhl-Olsen P, Thorn S, Frederiksen CA, Sloth E. Ultrasonography-guided radial artery catheterization is superior compared with the traditional palpation technique: a prospective, randomized, blinded, crossover study. *Acta Anaesthesiol Scand* 2014; 58: 446-52.
14. Seto AH, Roberts JS, Abu-Fadel MS, Czack SJ, Latif F, Jain SP, et al. Real-time ultrasound guidance facilitates transradial access: RAUST (Radial Artery access with Ultrasound Trial). *JACC*

- Cardiovasc Interv 2015; 8: 283-91.
15. Khilnani PK. Learning curve for arterial cannulation using ultrasound: a myth or reality? *Pediatr Crit Care Med* 2013; 14: 545-6.
 16. Lamperti M, Bodenham AR, Pittiruti M, Blaivas M, Augoustides JG, Elbarbary M, et al. International evidence-based recommendations on ultrasound-guided vascular access. *Intensive Care Med* 2012; 38: 1105-17.
 17. Roberts J, Manur R. Ultrasound-guided radial artery access by a non-ultrasound trained interventional cardiologist improved first-attempt success rates and shortened time for successful radial artery cannulation. *J Invasive Cardiol* 2013; 25: 676-9.
 18. Tang L, Wang F, Li Y, Zhao L, Xi H, Guo Z, et al. Ultrasound guidance for radial artery catheterization: an updated meta-analysis of randomized controlled trials. *PLoS One* 2014; 9: e111527.
 19. Troianos CA, Hartman GS, Glas KE, Skubas NJ, Eberhardt RT, Walker JD, et al. Special articles: guidelines for performing ultrasound guided vascular cannulation: recommendations of the American Society of Echocardiography and the Society Of Cardiovascular Anesthesiologists. *Anesth Analg* 2012; 114: 46-72.

เปรียบเทียบอัตราการความสำเร็จของการสอดสายเข้าหลอดเลือดแดง radial ด้วยเทคนิคอัลตราซาวด์และการคล้ำชีพจรในผู้ป่วยผู้ใหญ่

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ภูมิหลัง: การศึกษาก่อนหน้านี้รายงานความสำเร็จของการสอดสายเข้าหลอดเลือดแดงที่เพิ่มขึ้น โดยอัลตราซาวด์ในกลุ่มผู้ป่วยเด็กเมื่อเทียบกับการคล้ำชีพจรแต่ยังไม่สรุปชัดเจนถึงความสำเร็จในผู้ทำหัตถการที่มีประสบการณ์น้อยในเทคนิคอัลตราซาวด์ในผู้ป่วยผู้ใหญ่

วัตถุประสงค์: การศึกษานี้เปรียบเทียบการสอดสายเข้าหลอดเลือดแดง radial ด้วยเทคนิคอัลตราซาวด์และการคล้ำชีพจรในแง่ความสำเร็จ เวลาที่ใช้จำนวนครั้งของการแทงเข็ม

วัสดุและวิธีการ: การศึกษาเป็นแบบการศึกษาควบคุมแบบสุ่ม หลังจากผ่านการอนุมัติของกรรมการจริยธรรมในคนที่โรงพยาบาลศิริราช ในช่วงเวลาเดือนพฤศจิกายน พ.ศ. 2552 ถึง ตุลาคม พ.ศ. 2553 ผู้ทำหัตถการคือแพทย์ประจำบ้านชั้นปีที่ 3 จำนวน 10 คน โดยมีประสบการณ์การแทงหลอดเลือดโดยอัลตราซาวด์น้อยกว่า 3 ครั้ง ได้รับการฝึกปฏิบัติกับหุ่นจำลองเนื้อหมูก่อนเก็บการศึกษา ผู้ป่วย 10 คนต่อแพทย์ประจำบ้าน 1 คน ได้รับการแบ่งกลุ่มโดยการสุ่มเป็น 2 กลุ่ม ๆ ละ 5 คน กลุ่มอาศัยอัลตราซาวด์ (US-group) และกลุ่มอาศัยการคล้ำชีพจร (P-group)

ผลการศึกษา: ศึกษาในผู้ป่วยผู้ใหญ่ที่เข้ารับผ่าตัดศัลยกรรมระบบประสาท 100 คนไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติ ระหว่างกลุ่มอาศัยอัลตราซาวด์ (US-group) และกลุ่มอาศัยการคล้ำชีพจร (P-group) ในแง่ของความสำเร็จ (78% และ 82%; $p = 0.62$), เวลาที่ใช้ในการสอดสายเข้าหลอดเลือดแดงสำเร็จ (60 (12.8, 547.0) และ 52 (6.9, 639.0) วินาที; $p = 0.22$) (52.6±33.3 และ 36.1±24.7 วินาที; $p = 0.22$) และจำนวนการแทงเข็ม (1 (1, 3) และ (1, 4); $p = 0.82$) ความสำเร็จของการสอดสายเข้าหลอดเลือดแดง radial คือไม่เปลี่ยนตำแหน่งไปแขนอีกข้างผู้ทำหัตถการและเทคนิค

สรุป: ไม่พบความแตกต่างของความสำเร็จ เวลาที่ใช้ และจำนวนการแทงเข็มของการสอดสายเข้าหลอดเลือดแดง radial โดยอัลตราซาวด์เมื่อเทียบกับอาศัยการคล้ำชีพจร ผลการศึกษาต่างจากการศึกษาก่อนหน้านี้อาจเป็นได้จากประสบการณ์น้อยของผู้ทำหัตถการโดยเทคนิคอัลตราซาวด์ ขณะที่ประสบการณ์มากโดยเทคนิคคล้ำชีพจร