Optimal wrist angulation shortens time needed for radial artery catheterization: a prospective, randomized, and blinded study


Abstract: Introduction: Optimal wrist position is essential for successful catheterization of the radial artery. We planned to study the success rate of radial artery catheterization at various degrees of wrist extension angulations.

Methods: This prospective, randomized study was performed in 60 consenting patients aged between 18-65 years and undergoing variable surgeries where the anesthetic management required an arterial catheterization. All patients were randomized into three groups of 20 patients each, according to wrist angulation during radial artery catheterization: either 30° (Group 30), 45° (Group 45), or 60° (Group 60). Three metallic angulated wrist boards with angles of 30°, 45°, and 60° (angle measured with calipers) were prepared, on which patient’s wrist was kept at the above-mentioned angles of extension. Radial artery catheterization success rate, catheterization time, and numbers of attempts were recorded.

Results: The catheterization time was minimal in group 45 (30.50 ± 16.82 sec) as compared to 36.00 ± 14.19 sec and 43.50 ± 13.80 sec in group 30 and 60, respectively. Radial artery was catheterized at first attempt in 60% of Group 45 and Group 60 patients, and in 50% of Group 30 patients. The arterial catheterization was successful in 14/20 patients in Group 30, 19/20 patients in group 45, and 16/20 patients in group 60.

Conclusion: We conclude that a wrist extension of 45° appears to be the optimal wrist joint extension for a successful radial artery cannula insertion.

Key words: Radial artery; cannula insertions; wrist angulations; success rate.

Introduction

Arterial catheterization has become a common tool for the optimal management of several patients (1). Radial artery is the most preferred site, due to its consistent anatomic accessibility, ease of catheterization, and low rate of complications. In patients, radial artery catheterization has a higher failure rate than brachial or femoral artery catheterization. This is due to the small size of the radial artery at the wrist relative to the size of commonly used arterial puncture cannula (2).

Optimal positioning of the wrist is essential for a successful catheterization of the radial artery. This optimal positioning thereby reduces the incidence of complications. As the success of radial artery cannula insertion depends on the caliber of the radial artery, it is recommended to keep the wrist in an extended position (1). Overextension attenuates radial artery pulsations, and should be avoided. Hence, there is no established consensus on the optimal angulation.

Ultrasonographic evidence of the effect of wrist position on radial artery diameter has demonstrated that the antero-posterior diameter of the radial artery decreases when the wrist is extended to an angle of 60° in healthy subjects and 75° in patient’s having atherosclerosis (3). Ultrasonography may not be available at every place for artery catheterization. Hence we planned to study the success rate of radial artery catheterization at various degrees of wrist angulation in patients undergoing surgery, and who needed an invasive monitoring of blood pressure.

Methods

After Institutional Ethics Committee approval, this prospective, randomized, comparative study was conducted in 60 consenting patients aged between 18 and 65 years, and belonging to an ASA physical status group between I and III. Written informed consent for participating to the study was
obtained from all the patients. All were scheduled for elective surgery.

Patients having infection at the wrist, any coagulation disorder, positive modified Allen’s test, any peripheral occlusive vascular disease, previous surgery of the wrist, and congenital anomalies of the upper limb were excluded from the study.

After shifting the patients to the operating room, an intravenous line was secured and electrocardiography, non-invasive blood pressure and pulse-oximetry monitors were attached. All patients were anesthetized using a standard general anesthesia technique in the supine position. The non-dominant arm (mainly left arm) of the patient was kept 90° abducted and placed in the arm rest of the surgical table. Patients were randomly allocated to one of the following three groups of 20 patients each, using a computer-generated random number table. The three groups of patients were the following:

- **Group 30**, in which radial artery attempts of catheterization were performed at 30° of wrist extension.
- **Group 45**, in which radial artery attempts of catheterization were performed at 45° of wrist extension.
- **Group 60**, in which radial artery attempts of catheterization were performed at 60° of wrist extension.

Three angulated metallic wrist boards with respective angles of 30, 45, and 60° (angle measured with calipers) were prepared. They were covered using a thin opaque sterile sheet. The patient’s hand was kept in such a way that the dorsum of the hand lay within and the angle of the wrist (i.e. its extension) corresponded to the angle of the wrist mould (Fig. 1). The insertion field was cleaned and draped with a sterile opaque sheet. The radial artery catheterization was performed by different anesthesiologists, who had more than 100 successful radial artery cannula insertion experiences. Because of the drapes, the catheterizing anesthesiologist was not aware of the angulation. A 20-gauge arterial cannula was used for all patients. The catheterization technique consisted in an anterior wall puncture and direct arterial cannula threading. The angle of the needle to the skin ranged between 25 and 60°. Puncture occurred approximately 3 to 5 cm proximal to the most distal wrist crease. The needle and cannula were advanced until blood return was noted in the hub, signifying intra-arterial placement of the tip of the needle. A small amount of further advancement made the arterial cannula entering the anterior wall of the radial artery as well. Needle and cannula were then brought flat to the skin and the cannula advanced to its hub with a firm, steady rotatory action. Correct intra-arterial placement was confirmed by pulsatile free blood flow coming out of the cannula upon removal of the needle. If the initial attempt was unsuccessful, subsequent attempts were performed proximally to the distal wrist crease. More than three attempts were considered a failure.

During the radial artery catheterization, the following parameters were recorded by an independent observer:
Wrist Position for Radial Artery Cannula Insertion

189

maximally successful in Group 45 and least in Group 30 (14/20 patients in Group 30, 19/20 patients in Group 45, and 16/20 patients in Group 60), although these differences were not statistically significant ($\chi^2 (2) = 4.23$) (Table 2). No complications were observed in any of the three groups.

Discussion

We observed that the time needed for radial artery catheterization was significantly shorter when the wrist was kept flexed at 45° as compared to a wrist dorsiflexion of 60°. The total number of attempts was also lower, and the overall success rate of arterial cannula insertion was higher in group 45° as compared to Group 60° and 30°, although the differences were not statistically significant.

The earliest technique of arterial cannula insertion included direct surgical exposure (4). Subsequently, a palpatory method was used with variable success rate. Seldinger introduced the percutaneous method over a guidewire (5). Irrespective of the employed method, the insertion of the catheter can be difficult, requiring multiple attempts and causing patient discomfort. During catheterization, complications occur in only 1 to 5% of cases. These complications are of infectious, thromboembolic, and mechanical nature (6). The number of puncture attempts and small caliber of the artery have been associated with an increased risk of complications (7). Ultrasonography and doppler have been used to increase the success rate of radial artery cannula insertion (8, 9, 10, 11). However, these techniques require expertise, and may also not be available everywhere. Hence, inserting an arterial line in fragile patients requiring complex surgical procedures and needing it for optimal management may reveal complex in some situations.

During the conventional technique of radial artery cannula insertion, the wrist is dorsiflexed using various materials. With the pressure during cannula

\begin{table}
\centering
\begin{tabular}{|c|c|c|c|}
\hline
 & Group 30° & Group 45° & Group 60° \\
\hline
Age (years) & 43.2 ± 14.20 & 44.10 ± 13.58 & 38.05 ± 14.52 \\
Weight (kg) & 56.75 ± 10.37 & 57.70 ± 12.23 & 61.20 ± 14.91 \\
Height (cm) & 158.2 ± 9.88 & 160.40 ± 6.72 & 160.45 ± 7.60 \\
BMI (kg/m²) & 22.67 ± 3.82 & 22.31 ± 4.14 & 23.58 ± 4.32 \\
Male:Female (n) & 16:4 & 13:7 & 15:5 \\
\hline
\end{tabular}
\caption{Demographic Profile of patients in the three groups}
\end{table}

Statistical Analysis

The sample size was calculated based on a predicted difference of 20% in the catheterization time between the three groups (due to different wrist angulation) to be of clinical relevance, with a power of 80%, at an $\alpha$ threshold of 0.05. The actual power of our study based on catheterization time is 67%. The success rate and number of attempts were compared using chi-square tests. The time needed for cannula insertion was compared by using a one-way analysis of variance (ANOVA). Tests used for post hoc comparisons were two-tailed unpaired t tests, at a $\alpha$ threshold corrected for multiple comparisons. A $P$ value < 0.05 was considered as statistically significant for all comparisons made during the analysis.

Results

Sixty patients were enrolled in this randomized study and no patient was excluded from data analysis. The baseline demographic parameters were comparable in the three groups (Table 1).

The catheterization time was 36.0 sec, 30.5 sec and 43.5 sec., in Group 30, 45 and 60, respectively. There was a significant effect of group on catheterization time ($F_{2,59} = 3.79, P = 0.029$) (Table 2). Catheterization time was significantly longer in Group 45 than in Group 60 ($t_{37} = 2.67, P = 0.01$), but not than in Group 30.

The cannula was inserted into the radial artery at first attempt in 60% of patients in Group 45 and 60, and in 50% of patients in group 30 ($\chi^2 (2) = 0.61$, NS) (Table 2). The radial artery catheterization was

(1) Success rate: defined as the number of patients with successful placement of the cannula inside the radial artery.

(2) Catheterization time: time delay between the beginning of catheter insertion and successful placement inside the radial artery. Successful placement was decreed when blood aspiration from the distal end of the cannula was successful.

(3) Number of attempts: number of attempts needed for a successful placement of the cannula inside the radial artery.

Heart rate, mean blood pressure, and the occurrence of any complications during catheterization, such as hematoma, distal gangrene, or injury to nerves, were also recorded.

Data presented as mean ± SD or otherwise specified.
Our study is limited by the small sample size, the calculation of which was based on cannula insertion time. Recruitment of a larger number of patients is required to demonstrate a significant effect of angulation on success rate and number of attempts. Our findings may also not apply when another catheterization technique is used, such as a Seldinger technique.

We conclude that the optimal wrist angulation for radial artery cannula insertion seems to be 45° of dorsiflexion.

References