

Complications associated with the use of radial arterial catheters in relation to their length: Does size matter?

Fredy Alejandro Watts¹, Andres Ordoñez²,
Andres González³, Daniel Carvajal³, Jaime Quintero⁴
and Francisco L Uribe-Buritica¹ 

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Abstract

Background: Radial arterial catheters (RAC) are commonly used in emergency services and intensive care units (ICU) for continuous invasive monitoring of blood pressure and arterial blood gas sampling. Complications associated with RAC are rare. Regarding length of RAC catheters and complications, few studies were found in the literature. The present study seeks to provide health care professionals with scientific evidence to select an optimal length of RAC, based on the difference in the incidence of complications between ultrasound-guided catheters of the same diameter but different lengths.

Methods: Observational, descriptive, retrospective study. Patients older than 17 years admitted to the emergency department or ICU were included. RAC were placed with diameters of 20 gauge, between 5 and 8 cm (Arrow–Teleflex), and 22 gauge diameters between 4 and 8 cm (Vygon). Univariate analysis was made to determine behavior of the numerical variables. Normality of variables was determined through a Shapiro–Wilk-test. Qualitative variables were expressed in percentages, quantitative variables in means and standard deviation, or with median and quartiles in the case of a non-normal distribution. Chi-square or Fisher method was used for qualitative variables and the *t*-test for symmetric quantitative variables. Asymmetric distributions were processed with the Mann–Whitney *U* test. A value $p < 0.05$ was considered statistically significant. The statistical analysis was performed with Stata 14.1 program.

Results: About 793 RAC were placed between 2016 and 2019 were included, median age was 60 (37–73) (RIQ) years, 49% male. Complications were reported in all groups on average 17.5%, the most frequent being dysfunction/occlusion of the catheter. Given complications of the same diameter and different catheter lengths, there were no statistical differences between groups.

Conclusion: Selecting one length or another with a catheter of the same diameter does not have statistically significant differences, in terms of the complications this device may cause—meaning that size does not matter.

Keywords

Intensive care, techniques and procedures, catheters, nursing, ultrasonography—Doppler evaluation

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Background

(RAC) are commonly used in emergency services and intensive care units for continuous invasive monitoring of blood pressure and arterial blood gas sampling.^{1,2} The radial artery is the most commonly used for this procedure, due to its superficial location, and given that in most patients, circulation of the upper limb is determined by the ulnar artery.^{3,4} However, when cannulating a patient in the radial artery, the recommendation is to provide an ultrasound assessment of arterial diameter and blood flow as it has become the gold

¹Hospital Universitario Fundación Valle del Lili, Unidad de Urgencias, Unidad de Cuidado Crítico, Cali, Colombia

²Universidad ICESI, Facultad de Ciencias de la Salud, Postgrado Medicina de Emergencias, Cali, Valle del Cauca

³Facultad de Ciencias de la Salud, Programa de Medicina, Universidad ICESI, Cali, Valle del Cauca

⁴Centro de Investigaciones Clínicas (CIC), Hospital Universitario Fundación Valle del Lili, Cali, Colombia

Corresponding author:

Francisco L Uribe-Buritica, Hospital Universitario Fundación Valle del Lili, Unidad de Urgencias, Unidad de Cuidado Crítico, Cra 98 No 18-49, Cali 760032, Colombia.

Email: francisco.uribe@fvl.org.co

standard for insertion of RAC: blood supply can be determined indirectly and clinically with the Allen test.^{4,5}

Complications associated with RAC are rare, but one must identify them and make important therapeutic decisions. Scheer et al.⁶ performed a meta-analysis in which a total of 19,617 RAC catheters were evaluated, finding that the most frequent complication was temporary occlusion in 19%, followed by hematomas in 14%, local infection in 0.7%, bleeding in 0.5%, sepsis in 0.13%, and permanent ischemic damage in 0.09%. Among the associated risk factors, the most common were: multiple punctures, traumatic punctures, prolonged use of catheters (>48–72 h), and higher catheter/artery ratio, with a tendency to a higher rate of complications in the female gender due to smaller arterial diameters.^{4,6} Recently, Nuttall et al.⁷ carried out a retrospective study in which 62,626 patients were evaluated, with an arterial line placed, showing a complication rate of 3.4 per 10,000 inhabitants (CI 2.1–5.1).

Ultrasound for the insertion of RAC is now a common practice for physicians, and is shown to reduce complications.² Gao et al.⁸ performed a meta-analysis with the insertion of 447 catheters, guided by ultrasound and 455 catheters by anatomical reference, showing that the use of ultrasound increases the probability of effectiveness with the first attempt at cannulation, with an OR of 1.47 95% CI, 1.22–1.76; $p < 0.0001$. Current recommendations for catheter diameter suggest that 20 gauge catheters are most indicated, as they are associated with fewer complications compared to larger caliber catheters.^{4,5} Kim et al.⁹ conducted a controlled clinical trial with 80 elective surgery patients, randomly assigning 20 gauge catheters versus 22 gauge. In this study, no statistically significant differences were found between complications with the two diameters. As such, 20 gauge catheters are recommended, as they are associated with fewer complications.

Regarding length of RAC and complications, few studies were found in the literature. Dahl et al.¹⁰ conducted a randomized controlled clinical trial in 82 patients scheduled for elective vascular surgery, in which RAC, with a length of 15.2 cm versus 4.45 cm, were used; this led to finding a lower incidence of occlusion with 15.2 cm catheters ($p = 0.05$) but a higher incidence of hematomas in the 4.5 cm group ($p = 0.02$). However, we have not yet found recent studies or sufficient epidemiological support to conclude which catheter length is associated with a lower incidence of complications. The present study seeks to provide health professionals with scientific evidence to select an optimal length of RAC, based on the difference in the incidence of complications between ultrasound-guided catheters of the same diameter but different lengths.

Methods

This is an observational, descriptive, and retrospective study. Patients older than 17 years admitted to the emergency

department or intensive care unit in a high-complexity institution (Hospital Universitario Fundación Valle del Lili) between January 1, 2016 and March 1, 2019, were included. RAC were placed for invasive monitoring or frequent blood extraction for studies. The available catheters were 20 gauge radiopaque polyurethane catheter, 5 or 8 cm (Arrow – Teleflex, Wayne, PA, USA), and 22 gauge (Vygon, Ecouen, France, radiopaque polyurethane). All catheters were placed by physicians with certified ultrasound training, in-plane (longitudinal) view projection with the Seldinger technique, complying with institutional protocol. Exclusion criteria were not generated. The choice of the vascular device was at the discretion of the physician who performed the procedure, accounting for the radial arterial diameter by ultrasound in selecting the caliber of the catheter. About 5379 patients who met the eligibility criteria were consecutively included during the established period. Data were collected in an institutional database (BDClinic) of the Clinical Research Center of the Fundación Valle del Lili University Hospital. This protocol was approved by the institutional medical ethics committee. No funding was received.

Patients were grouped according to caliber of the catheter, as measured by gauge. Institutional protocol for insertion of an RAC, assisted with ultrasound, can be applied to patients with two failed anatomical cannulation attempts by nursing personnel, or risk factors of bleeding (use of anticoagulants). All specialist physicians who performed the procedure are trained in ultrasound-guided venous access.

A sample size calculation was performed, considering the percentage of the most frequent complication reported (19% temporary occlusion),⁶ considering a 95% CI for groups of 227 patients in each arm. Patient medical records, for those who met selection criteria, were reviewed, while variables of interest for each patient were collected. Adverse events were investigated, such as hematoma, dysfunction or occlusion, distal limb ischemia or local infection, with the catheter's length of time considered. An exploratory analysis of the data was then carried out, randomly taking 10% of them and comparing data entered against source documents, evidencing its reliability.

A univariate analysis was carried out to determine behavior of the numerical variables. Normality of variables was determined through a Shapiro Wilk test and those with a $p > 0.05$ were considered to have a normal distribution. Qualitative variables were expressed in percentages, while quantitative variables were summarized with means and standard deviation, or with median and quartiles in the case of a non-normal distribution. The Chi-square or Fisher method was used for qualitative variables and the t -test for symmetric quantitative variables. Asymmetric distributions were processed with the Mann-Whitney U test. A p value < 0.05 was considered statistically significant. The statistical analysis will be performed with the Stata 14.1 program (StataCorp. 2015. Stata Statistical Software Release 14. College Station, TX, USA: StataCorp LP).

Table 1. Demographic Characteristics

	Total	Catheter			
		20 G × 5 cm	20 G × 8 cm	22 G × 4 cm	22 G × 8 cm
N	793	200	200	193	200
Age	60 (37–73)	58 (37–72)	59 (36–71)	60 (36–74)	63 (38–74)
Male n (%)	387 (49)	102 (51)	112 (56)	78 (40)	95 (48)
Medical history					
Hypertension n (%)	363 (46)	89 (45)	102 (51)	82 (42)	90 (45)
Diabetes mellitus n (%)	174 (22)	38 (19)	49 (25)	43 (22)	44 (22)
Chronic renal disease n (%)	157 (20)	43 (22)	34 (17)	34 (18)	46 (23)
Heart failure n (%)	143 (18)	33 (17)	34 (17)	42 (22)	34 (17)
Cancer n (%)	120 (15)	29 (15)	19 (10)	35 (18)	37 (19)
Coronary heart disease n (%)	96 (12)	26 (13)	21 (11)	18 (9)	31 (16)
Organ or tissue transplantation n (%)	59 (7)	20 (10)	12 (6)	13 (7)	14 (7)
Chronic obstructive pulmonary disease n (%)	54 (7)	17 (9)	12 (6)	15 (8)	10 (5)
Peripheral vascular disease n (%)	40 (5)	5 (3)	8 (4)	15 (8)	12 (6)
Rheumatologic disease n (%)	38 (5)	13 (7)	3 (2)	12 (6)	10 (5)
Hematologic disease n (%)	28 (4)	5 (3)	8 (4)	8 (4)	7 (4)

Table 2. Median days of arterial catheter use.

Days of catheter use ^{***}	
Total	4 (2–9)
20 × 5	4 (2–9)
20 × 8	4 (2–10)
22 × 4	4 (2–8)
22 × 8	4 (2–9)

***Median (IQR).

Results

A total of 793 RAC were placed between 2016 and 2019 were included in the study after randomizing patients, the median age was 60 years, 49% was male, while patients were divided into four equitable groups according to type of catheter used (20 G × 5 cm, 20 G × 8 cm, 22 G × 4 cm, and 22 G × 8 cm) (Table 1).

The median use of RAC was 4 days RIQ (2–9) (Table 2). Complications were reported in all groups on average 17.5%, the most frequent being dysfunction/occlusion of the catheter. Given complications of the same diameter and different catheter lengths, there were no statistical differences between groups.

Discussion

Our research found there were no statistically significant differences in the frequency of complications between RAC of different lengths and the same diameter. For the 20 G × 8 cm group, dysfunction/occlusion was the most frequent complication compared to the 20 G × 5 cm group ($p=0.63$), but for the 20 G × 5 cm group, hematoma was more frequent compared to the 20 G × 8 cm group ($p=0.37$). However, for the

Table 3. Catheter complications associated with 22 G × 4 cm and 22 G × 8 cm (Vygon).

Complication	Catheter		p Value
	22 × 4, n = 193	22 × 8, n = 200	
Yes n (%)	37 (19)	40 (20)	0.899
Hematoma	5 (2.5)	7 (3.5)	0.771
Dysfunction/Occlusion	27 (13)	23 (11)	0.545
Ischemia	0	2 (1)	0.499
Local infection	0	2 (1)	0.499
Other	6 (3)	12 (6)	0.228

22 G × 4 cm group, dysfunction/occlusion was the most frequent complication compared to the 22 G × 8 cm group ($p=0.54$), but for the 22 G × 8 cm group, the formation of other complications was more frequent versus the 22 G × 4 cm group ($p=0.22$) (Tables 3 and 4).

Risk factors related to complications with the use of a RAC in our population were: medical history of arterial hypertension, chronic kidney disease, and diabetes mellitus. These results should create awareness of the possible relationship between the disease and the medical history of the patient, as well as the incidence of complications associated with the use of RAC.

In Dahl's et al.¹⁰ clinical trial in 1992, a lower incidence of occlusion with the use of 15.2 cm catheters ($p=0.05$) was observed, but there was a higher incidence of bruising, compared to the 4.5 cm group of patients ($p=0.02$). Looking at our study with a larger population, the data indicated that there was no difference in number of complications when using one length or another, so selection should not be based on this

Table 4. Catheter complications associated with 20 G × 5 cm and 20 G × 8 cm (Teleflex).

Complication	Catheter		p Value
	20 × 5, n = 200	20 × 8, n = 200	
Yes n (%)	31 (15)	31 (15)	1
Hematoma	4 (2)	1 (0.05)	0.372
Dysfunction/Occlusion	21 (10)	24 (12)	0.635
Ischemia	0	0	NA
Local infection	0	0	NA
Other	9 (4.5)	6 (3)	0.43

characteristic, as no statistically significant variability was evidenced between groups.

Although these results do not agree with preexisting information in this study, it can be explained: two different lengths were compared and our sample size was significantly larger, in that all procedures were performed under ultrasound guidance.

Within these limitations, it is seen that the CI reached in the development of this study is between 90% and 95%, to achieve an interval greater than 95%, which occurs due to the deficit of 27 patients in the four different groups, when the sample calculation was created ($n=227$ for each group). Another limitation of the study occurred with data collection, specifically in the selection of management diagnosis, as several patients had a disease and also suffered from underlying pathologies that affect true value statistics of the risk factors with complications. We did not consider the diameter of the artery in relation to the catheter, as the doctor selects one after ultrasonography of the artery.

This highlights the strengths of our study, including sample size, which can be considered larger than that of previous studies. An attempt was also made to cover a greater number of variables to define the type of catheter to be safely used to reduce frequency of complications and define risk factors most associated with them.

Conclusion

In conclusion, selecting one length or another with a catheter of the same diameter does not have statistically significant differences, in terms of the complications this device may cause—meaning that size does not matter, which answers our title question.

Declaration of conflicting interests

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ORCID iD

Francisco L Uribe-Buritica  <https://orcid.org/0000-0003-4929-3660>

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