A comparison between Invasive and Non-Invasive Blood Pressure monitoring for postoperative patients in Cardiac Intensive Care Unit

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Abstract:

Background: Blood pressure monitoring is essential for hemodynamically ill patients in Intensive Care Unit. Invasive measurement from an arterial line is considered as the method of choice in spite of the errors that may occur due to calibration error, movement artifacts and over or under damping. Furthermore, because of the frequent need for continuous and prolonged monitoring of blood pressure for critically ill patient in cardiac intensive care unit, automated noninvasive blood pressure measurements are commonly used.

Objective: To compare Invasive with Non Invasive Blood Pressure. And to observe whether femoral and radial arterial lines can be used interchangeably in cardiac intensive care unit.

Methods: 70 patients were divided into two equal groups. First group underwent standard femoral artery catheterization for invasive blood pressure monitoring. The second group underwent standard radial artery catheterization for invasive blood pressure monitoring. A cuff was placed in the arm for noninvasive monitoring for all 70 patients. For each patient data were obtained by performing noninvasive blood pressure measurement for 4 times which was at time of admission to intensive care unit (T1), one hour later (T2), two hours later (T3) and three hours after admission (T4). At the same time the invasive blood pressure measurement was recorded for comparison.

Results: There were significant differences between diastolic invasive blood pressure measurement obtained from femoral arterial line or radial arterial line with diastolic noninvasive blood pressure measurement. No significant statistical difference in mean arterial pressure between invasive and noninvasive blood pressure was detected.

Conclusion: Noninvasive blood pressure measurement alone is insufficient for monitoring of postoperative patients admitted to cardiac intensive care unit after cardiac operation. And femoral or radial arterial line can be used interchangeably for blood pressure monitoring in cardiac intensive care unit.

Keywords: Invasive blood pressure monitoring, Noninvasive blood pressure monitoring, Femoral arterial line, Radial arterial line, Cardiac intensive care unit.

Introduction:

Percutaneous arterial cannulation is widely used in clinical management of critically ill patient [(1)]. Arterial monitoring allows uninterrupted display of pulse contour and continuous real time heart rate and blood pressure measurement. The intra-arterial catheter is inserted percutaneously via a number of superficial arteries, including radial, femoral, brachial, axillary and dorsalispedis [(1)]. However, arterial cannulation is not free of risk, and

clinician must weigh the risk to benefit ratio. Iatrogenic injuries is related to morbidity, prolonged length to stay, financial excess, and appreciable long term injury of medico legal significance. And due to the frequent need for prolonged monitoring of blood pressure among critically ill patients, automated oscillometric NIBP measurements are commonly used in ICU [2]. Furthermore, NIBP is accepted as the standard monitoring modality in most clinical settings [3]. And when there is a need for accurate and reliable beat to beat monitoring of blood pressure, an intra-arterial catheter is considered the standard [4]. The superiority of the invasive monitoring led many practitioners to neglect NIBP monitoring in patients once such a catheter is placed [5].

In this study, we tested the accuracy of NIBP in comparison with IBP and the interchangeability between femoral and radial arterial catheterization for postoperative patients in cardiac ICU.

Aim:

To compare femoral and radial arterial blood pressure monitoring with noninvasive automated oscillometric blood pressure monitoring for postoperative patients in cardiac ICU. Also, to observe if radial and femoral arterial blood pressure monitoring can be used interchangeably in cardiac ICU.

Methods:

This is a prospective comparative study conducted in our center. Seventy patients underwent cardiac surgery were enrolled in this study after getting their consent approval. The demographic Data (age, gender, time of operation, type of operation, and history of hypertension) were recorded.

Inclusion Criteria:

- postoperative patients undergoing elective cardiac operation
- Left ventricular ejection fraction more than (40%).
- ASA II-III

Exclusion Criteria:

- Non cardiac disease patients, shock, sepsis, renal failure, hepatic failure, ASA IV or more, patients with previous CABG, patients on intra-aortic balloon (IAB), patients underwent re-do operation.

Study Design:

This was acomparative study of two groups:

1. First group: included 35 patients and all they underwent standard femoral arterial line for invasive blood pressure monitoring
2. Second group: included 35 patients and they all underwent standard radial arterial line for blood pressure monitoring.

A cuff was placed in the arm for automated oscillometric NIBP monitoring for all 70 patients. The cuff size for adult was either 16×30 cm or 16×36 cm and for pediatric patients the size was 6×12 cm.The monitor used in this study to obtain the IBP and NIBP was DatexOhmeda S/5. Data were obtained by recording 4 readings for NIBP; at the same time IBP for femoral or radial arterial line was recorded. Flushing of the arterial line with (0.9%) heparinized normal saline and zeroing to the electronic system were performed regularly before each reading. Systolic, diastolic and mean arterial pressures (MAP) were recorded for both NIBP and IBP in each reading. The MAP is usually calculated by using the equation: (systolic+2*diastolic)/3, however, in the

new monitors, the MAP will be given automatically.

The following data points were defined: T1=measuring NIBP and IBP at time of admission to ICU; T2= measuring NIBP and IBP one hour after admission; T3= measuring NIBP and IBP two hours after admission; T4= measuring NIBP and IBP three hours after admission to ICU.

Descriptive statistics of variables were presented as mean and standard deviation (SD) for continuous variables (age, gender, type of operation and history of hypertension). Comparison of means and the significance of difference in between study groups were tested by students' test (independent two groups' type) for all continuous variables. Chi square was used in comparison of categorical variables. Level of significance (P value) of $\leq$ 0.05 considered as significant difference, P $\leq$ 0.001 considered as highly significant.

Results:

There were 70 patients in this study, all admitted to cardiac ICU for postoperative monitoring and management after cardiac operation. Patients were assigned into two groups, each group had 35 patients.

The mean age of patients in the first group (femoral) was 55.93 years.

The mean age of patients in the second group (radial) was 55.90 years.

The vast majority (90%) of the patients were located between 40 – 80 years. The mean age for participants was 56 years with a S.D of 17 years. The age of study sample was ranging from one to 81 years.

The majority of patients were male; representing (60%) of the whole study sample as it shown in figure (2). And (55.7%) of the patients had history of hypertension as it shown in the figure (3).

After analyzed data from table (1) indicate that after comparing between males and females for many variables, there was no statistically significant difference between them.

After comparing between femoral and radial mean blood pressures for many variables, there was no statistically significant difference between them, table (2).

A comparison between systolic BP for invasive and noninvasive was done and it did not show any significant difference. T-Test of two samples was used P – value was 0.77. The results are shown in table (3).

There was a statistically significant difference between invasive and non-invasive methods regarding diastolic BP. T – Test of two independent samples was performed to find the relation, it was significant and P – value was 0.04. The results are shown in table (4).

The difference of MAP for invasive method did not differ significantly with that ofnon-invasive technique. T – Test of two samples was used and P – value was 0.18. And the results are shown in table (5).

There was no any difference between hypertensive and non-hypertensive participants in regard to invasive BP, P – value was 0.20. While there were significant statistical differences between hypertensive and non-hypertensive patients in NIBP concerning other factors (variables); in all circumstances the mean of hypertensive group was higher than that of non-hypertensive patients; the results are shown in table (6).

There was statistically significant relationship between hypertension and

different age groups, hypertensive patients tended to be more in elder than non-hypertensive participants. Chi square test was used and P – value was 0.01. The results are shown in table (7). There was no significant relation between gender and hypertension. P – Value was more than 0.49.

And no statistical significant association has been found between hypertension and type of operation. The analysis was done by Pearson Chi-Square test; P – value was 0.06. Results are shown in table (8) and (9).

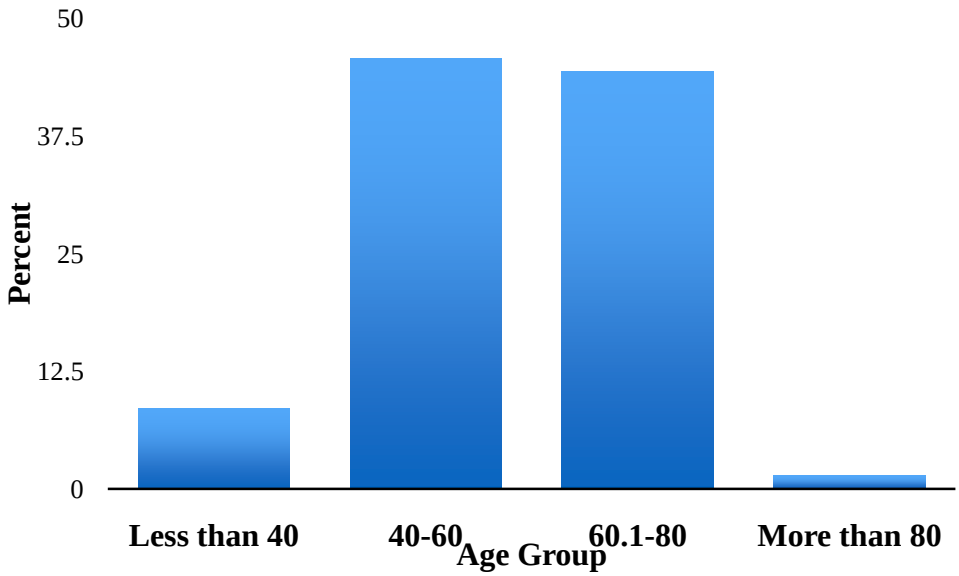

Figure (1): Age distribution of participants.

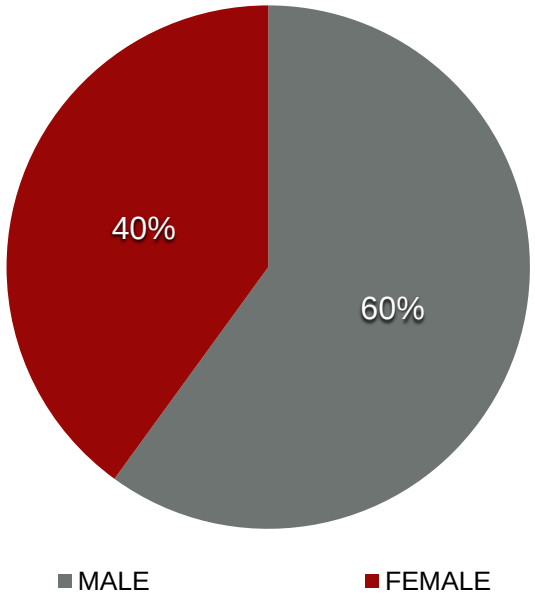

Figure (2): Gender distribution.

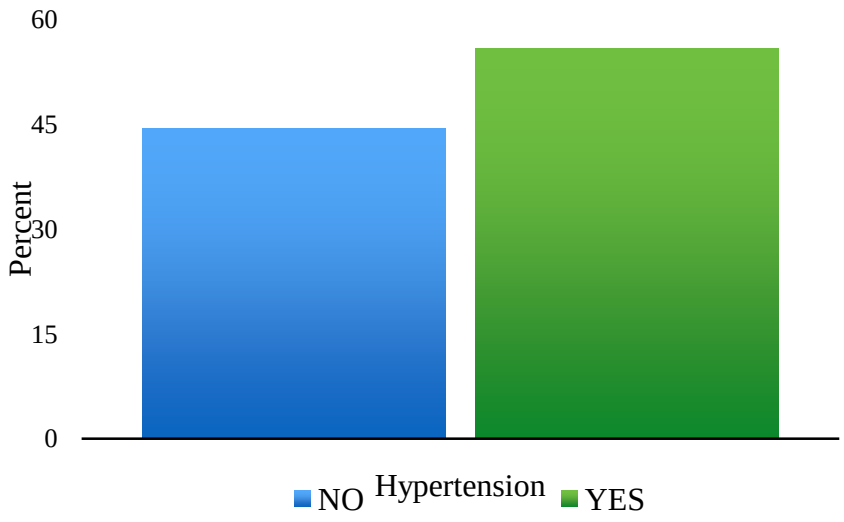

Figure (3): Hypertension distribution.

Table (1): Differences between males and females.

Variables	Gender	N	Mean	S. D	P – Value
Inv. Syst	Male	42	126.2	19.9	0.420
	Female	28	122.4	19.0	
Inv. Dias	Male	42	70.69	13.4	0.744
	Female	28	69.61	13.5	
MAP	Male	42	90.60	14.4	0.640
	Female	28	88.98	13.7	
Non. Syst	Male	42	125.8	15.8	0.204
	Female	28	120.9	15.3	
Non. Dias	Male	42	75.84	11.1	0.297
	Female	28	72.81	12.7	
MAP	Male	42	94.56	12.3	0.213
	Female	28	90.63	13.5	
Age	Male	42	56.74	15.9	0.646
	Female	28	54.82	18.5	

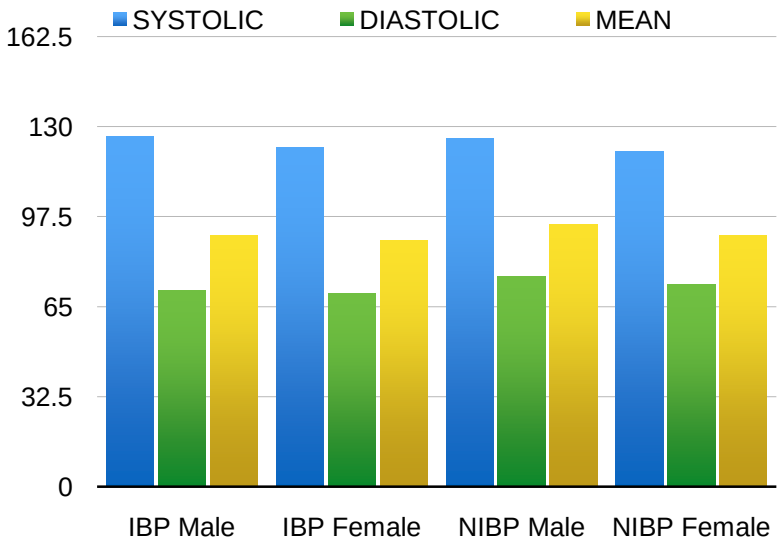

Figure (4): Differences between males and females.

Table (2): Differences between Femoral and Radial Mean arterial pressures.

Variable	Site	N	Mean	S. D	P – Value
Inv. Syst	Femoral	35	125.8	17.1	0.63
	Radial	35	123.6	21.8	
Inv. Dias	Femoral	35	70.62	13.6	0.82
	Radial	35	69.90	13.3	
MAP	Femoral	35	90.56	14.4	0.72
	Radial	35	89.35	13.9	
Non. Syst	Femoral	35	120.5	16.9	0.07
	Radial	35	127.2	13.7	
Non. Dias	Femoral	35	73.57	12.3	0.45
	Radial	35	75.69	11.4	
MAP	Femoral	35	92.08	13.9	0.55
	Radial	35	93.90	11.8	
Age	Femoral	35	55.34	20.1	0.75
	Radial	35	56.60	13.2	

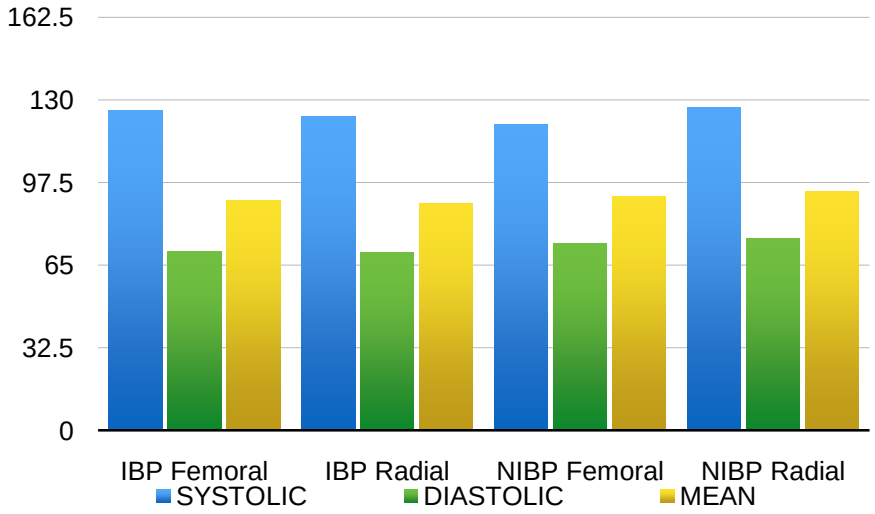

Figure (5): Differences between Femoral and Radial Mean arterial pressures.

Table (3): Difference of systolic BP between Invasive and Non – invasive methods.

Systolic BP	No.	Mean	S. D	P - Value
Invasive	70	124.74	19.53	0.77
Non-invasive	70	123.90	15.71	

Table (4): difference of diastolic BP between Invasive and Noninvasive technique.

Diastolic BP	No.	Mean	S. D	P - Value
Invasive	70	70.26	13.42	0.04
Non-invasive	70	74.63	11.84	

Table (5): Variation of MAP between Invasive and Non – invasive approaches.

MAP	No.	Mean	S. D	P - Value
Invasive	70	89.95	14.09	0.18
Non-invasive	70	92.99	12.87	

Table (6): Variations between hypertensive and non-hypertensive patients.

Variable	HTN	N	Mean	S. D	P - Value
Inv. Syst	NO	31	121.2	23.5	0.20
	Yes	39	127.5	15.4	
Inv. Dias	NO	31	66.29	15.9	0.02
	Yes	39	73.41	10.2	
Inv-MAP	NO	31	85.78	17.3	0.02
	Yes	39	93.27	9.90	
Non. Syst	NO	31	119.5	16.8	0.03
	Yes	39	127.3	13.9	
Non. Dias	NO	31	70.75	12.3	0.01
	Yes	39	77.71	10.6	
Non-Inv-MAP	NO	31	88.37	13.2	0.01
	Yes	39	96.66	11.4	
Age	NO	31	46.55	19.3	0.01
	Yes	39	63.46	9.7	

Table (7): Relationship between hypertension and age.

Age groups (Years)		Hypertension		Total
		NO	Yes	
< 40	Count	6	0	6
	% within Hypertension	19.4%	0.0%	8.6%
40 - 60	Count	15	17	32
	% within Hypertension	48.4%	43.6%	45.7%
60.1 - 80	Count	10	21	31
	% within Hypertension	32.3%	53.8%	44.3%
> 80	Count	0	1	1
	% within Hypertension	0.0%	2.6%	1.4%
Total	Count	31	39	70
	% within Hypertension	100.0 %	100.0 %	100.0 %

Table (8): Relationship between hypertension and gender.

Gender		Hypertension		Total
		NO	Yes	
Male	Count	20	22	42
	% within Hypertension	64.5%	56.4%	60.0%
Female	Count	11	17	28
	% within Hypertension	35.5%	43.6%	40.0%
Total	Count	31	39	70
	% within Hypertension	100.0 %	100.0 %	100.0 %

Table (9): Association between hypertension and type of operation.

Type of operation		Hypertension		Total
		NO	Yes	
ASD	Count	3	0	3
	% within HTN	9.7%	0.0%	4.3%
CABG	Count	21	35	56
	% within HTN	67.7%	89.7%	80.0%
MVR	Count	4	4	8
	% within HTN	12.9%	10.3%	11.4%
TOF	Count	1	0	1
	% within HTN	3.2%	0.0%	1.4%
VSD & PDA	Count	2	0	2
	% within HTN	6.5%	0.0%	2.9%
Total	Count	31	39	70
	% within HTN	100.0 %	100.0 %	100.0 %

Discussion:

Our data showed a discrepancy between IBP and NIBP, supporting the use of IBP, whether femoral or radial, in monitoring and to guide treatment decision. Clinically relevant observations were detected in this study.

First, we observed that there is a significant statistical difference in diastolic blood pressure measurement between NIBP and IBP (for both femoral and radial arterial line), P –value was 0.04. This result came with a research conducted by:

- Wax David, Lin Hung Mo, Leibowitz Andrew in November 2011. In this research, which was performed during intraoperative period, the result showed that NIBP (mainly diastolic) is higher than IBP when the latter is low and lower when the IBP is high [(5)].
- Avolo AP, Van Bortel LM, Boutouyrie P. Cockcroft JR, McEniery CM, which was conducted in 2009 and dealt with the Role of pulse pressure

amplification in arterial hypertension [7].

On the other side, our results came against the researchers conducted by:

- Kim Won Young, Jun, Jong Hun, Hong, Sang Bum. In December 2013, however, this research was mainly for shock patient receiving high dose of norepinephrine [8].
- Li Wei H. Lehman, Mohammed Saeed, Daniel Talmor, Roger Mark, in this study that was conducted in 2013, the significance difference between IBP and NIBP was with systolic blood pressure. While diastolic blood pressure showed no significance difference [9].

Second, there are no significant changes in systolic, diastolic and MAP between radial and femoral IBP. And P – value was more than 0.05 for all. This result came with the research conducted by:

- Hohn A., Defosse J.M., Becker S., Steffen C., Wappler F., Sakka S.G. in March 2013, which concluded that radial and femoral arterial can be interchangeable [10].
- Mignini Mariano Alejandro, Piacentini Enrique in 2006 which concluded that there is no significant difference between radial and femoral line and they can be used interchangeably [6].

Our result regarding the difference between radial and femoral invasive blood pressure monitoring came against the result conducted by:

- Dorman T et al in 1998 which concluded that radial artery underestimate femoral artery pressure during vasopressor therapy in critically ill surgical patients [11]. The sample of patients used in this research was shock patient which were excluded in our study.
- Third, our results showed that there is no significant difference between MAP for both NIBP and IBP (whether femoral or radial) and P – value was 0.18. Therefore, our results confirm that mean blood pressure is the most significant metric for monitoring blood pressure in the ICU and it is independent of measurement modality. It is important to mention that current practice guidelines have been slow to integrate NIBP MAP in vital sign monitoring [9]. For example, the American Heart Association definition of hypertension is based on systolic and diastolic blood pressure only [12]. And the Society for Critical Care Medicine has utilized both systolic and MAP for defining sepsis induced hypotension, whereas MAP was used in setting therapeutic goals [9].

Our study regarding the MAP came with other researchers conducted by:

- Li Wei H. Lehman, Mohammed Saeed, Daniel Talmor, Roger Mark. In 2013, which concluded that mean pressure is the true driving pressure for peripheral blood flow [9].
- Pinsky MR, Payen D in 2005 [13].

And our study came against the result conducted by Wax David, Lin Hung Mo, Leibowitz Andrew in 2011, which showed that there are clinically significant difference between MAP measured invasively and noninvasively. And NIBP is generally higher the IBP when the latter is low and lower when IBP is high [5].

Fourth, our results showed that patients with history of hypertension have significant difference compared with non-hypertensive patients in NIBP, and P – values were less than 0.05 while there was no any difference between hypertensive and non-hypertensive participants in

regard to invasive BP, P – value was 0.20. All measures for hypertensive patients were higher than non-hypertensive patients in NIBP. These results came similar to other studies conducted by:

- Nielson PE, Larsen B, Holstein P, Poulsen HL in 1983 which showed increase difference between hypertensive and non-hypertensive patients in NIBP [14].

However, this study depended on auscultatory method in measuring NIBP, rather than oscillometric method which were depended in our study.

- Araghi et al which was published in 2006, however, this study was concerned mainly about overweight critically ill patients [15].

Fifth, our results showed a statistically significant relationship between hypertension and different age groups. Hypertensive patients belonged more to elder age group. This result came with the results conducted by:

- Aronson S, FontesML [16].
- Franklin SS, Larson MG, Khan SA, et al [17].

Both studies mentioned that the frequency increases with the age of the population with nearly two thirds of hypertensive being older than 50 years [16, 17].

Finally, the results conducted by our study showed that there are no statistically significant changes between hypertension and gender or type of operation.

This result came with the results conducted by:

- Nwankwo Tatiana, Yoon Sung, Burt Vicki, QiupingGu. This study concluded that the prevalence of hypertension was similar for men and woman, and the factors that affect hypertension are age and race [18].

Our study has a number of strengths, including the focus on single group of cardiac ICU which is the postoperative patients. Also, the patients involved in this study belonged to wide range age group, starting from 1 year old to 82 year old. Furthermore, all the data of this study were collected in a well-equipped tertiary center with well- trained nurse staff in cardiac ICU. It is important to mention that source of error and accuracy problems can easily associate such kind of study due to different age group, presence of arrhythmia, inaccurate cuff selection, and positioning [19]. Therefore, the presence of well-trained nurse staff is crucial in overcoming the obstacles that can lead to errors and inaccuracy in data collection.

Conclusion:

NIBP alone is insufficient for BP monitoring for postoperative patients in cardiac ICU. Although IBP may carry different complications, yet, it is still the method of choice for BP monitoring in cardiac ICU. Site for arterial line (femoral or radial) will give the same results in BP monitoring. And each arterial cannulation site has distinct advantages and disadvantages that should be considered by the clinician.

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