

Improving Patient Care Through Quality Improvement Initiative: A Study of Knowledge, Practice, and Skill Among Interns and Residents on Arterial Puncture for Arterial Blood Gas Analysis at a Tertiary Teaching Hospital in Rural Gujarat

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ABSTRACT

Aims and Background: Arterial Blood Gas Analysis (ABG) is an indispensable diagnostic tool offering swift and comprehensive insights into a patient's ventilation, gas exchange, and acid-base equilibrium. Though seemingly straightforward, the procedure of collecting arterial blood for ABG analysis carries inherent risks and complications, especially when performed by untrained individuals or under time constraints. Recognizing the prevalence of non-uniformity and errors in drawing arterial blood, this Quality Improvement Initiative was conducted. The primary objectives included setting standard goals with performing the Modified Allen Test being the most crucial for Radial Artery puncture, assessing quality, identifying deficits through observation and interviews, implementing educational interventions, and reassessing quality to enhance procedural accuracy.

Methods: A Quality Improvement Study of arterial puncture was conducted with 22 participants (interns, postgraduate students, fellows) in a Tertiary Teaching Hospital's Emergency and Critical Care Units. After identifying the deficits, educational interventions were implemented and a reassessment was conducted.

Results: The Modified Allen Test was not performed by any of the participants and only 40.9% of participants applied firm and immediate pressure at the puncture site with a gauze/cotton for 3-5 minutes. Post-intervention, a 100% result was achieved with all the participants performing the Modified Allen Test and applying firm, immediate pressure.

Conclusion: There are discrepancies while collecting arterial blood for ABG analysis. An emphasis on formal training is required to address these knowledge and procedural shortfalls which if not taken care of may lead to serious complications that are detrimental to patient health.

Keywords: Quality Improvement Initiative, Modified Allen Test, Radial artery puncture, ABG analysis, Clinical Audit, Critical care

INTRODUCTION

Arterial Blood Gas Analysis (ABG) is one of the most common tests performed in emergency and critical care setups. As a single test that gives quick and near complete information about ventilation, gas exchange, and acid-base balance in the patient, it is lifesaving. It also helps in triage and guides decision-making with regards to admission area. Serial ABGs help follow the progress of patients guiding important clinical decisions.

The procedure appears relatively simple and involves puncturing an artery- radial and femoral being commonly used sites, with a heparinized syringe to collect around 1 ml blood which is then analyzed in the blood gas analyzer and report generated within minutes.

However, like any procedure in clinical medicine, this too is associated with risks and complications if performed by unskilled, untrained hands and if the steps are not followed in order and performed accurately. What also increases the possibility of errors and hence complications, is the fact that these procedures are usually performed in busy areas, on critical patients, under time constraints, or in emergency settings. An added factor, which is present at many centers, especially teaching hospitals is that the procedure is performed by interns posted in these units or first-year postgraduate students attending to the patient. This group is usually not given any formal training and the learning happens on the go or by observing seniors. Even in experienced hands, this procedure, if not done properly can lead to complications, which can range from hematoma at the site of puncture to compartment syndrome.

During their work, the investigators identified the problem of non-uniformity and errors in the technique of the procedure in point (arterial puncture for ABG analysis). It was hence decided to conduct a to address this problem. Once the standard goals were set based on the existing

literature and the study design decided; a proposal was submitted to the QI group. Quality was assessed by observing and interviewing the concerned group. Once the areas needing change were identified, educational material was prepared and presented to the group. Quality was then reassessed and recorded. With more and more varied procedures being performed at the bedside in busy areas, Clinical Audits are an indispensable tool to improve processes and hence patient care and outcomes.

MATERIALS & METHODS

Review of literature:

A literature search was done using keywords and their combinations, ABG, Arterial Blood Gas Analysis, Arterial puncture, Complications. Appropriate articles were selected and saved to Zotero.

Arterial Blood Gas analysis is one of the most commonly performed tests in emergency and critical care settings guiding patient management pathways. A single patient may need to undergo the test multiple times a day in certain settings, making it extremely important for healthcare professionals to be well-versed in the procedure and interpretation of the report. As the name itself suggests, it involves puncturing of an artery, common sites being the radial and femoral arteries with radial more frequently used due to the ease of access. If not done properly, it has the potential to lead to catastrophic complications.

If we revisit the hand's anatomy, the blood supply to the volar/palmar surface originates from the radial and ulnar arteries. As they cross the wrist and reach the palm, they anastomose to form two arches called the superficial and the deep volar arch. In turn, these arches, along with their branches and their abundant network of blood vessels provide oxygenated blood to the musculoskeletal components of the hand and fingers.

Anatomical variation however exists.⁽¹⁾ This should be kept in mind during medical procedures involving puncture and precautions should be taken to prevent iatrogenic ischemic hand complications.⁽²⁾ One such simple precaution before puncturing the radial artery is Modified Allen's test, a simple bedside test, to assess collateral blood flow to the hands.⁽³⁾ It is important to perform this test before performing arterial puncture during sample collection for ABG analysis.^(4,5) Besides ischemic complications like finger necrosis,⁽⁶⁾ other complications like hematoma, compartment syndrome,⁽⁷⁾ and aneurysm of the artery, are reported as case reports.⁽⁸⁾ Rowling SC, Fløjstrup M, Henriksen DP, et al. analyzed 473 327 arterial punctures and found 669 (0.14%, 95% CI 0.13–0.15) arterial punctures led to major complications: embolisms or thrombosis (49.0%), aneurysms (15.4%), nerve damage (1.5%), arteriovenous fistulas (0.6%) or of another kind (33.5%). They also noted that identified major complication rates in patients on antithrombotic medication were increased (OR 1.31, 95% CI 1.07–1.61).⁽⁹⁾ We came across studies to assess the knowledge regarding ABG among nurses. Studies carried out to assess the effectiveness of a teaching program on knowledge regarding ABG amongst nurses.⁽¹⁰⁾ There is also the ABG needle study- a randomized control study comparing 23G versus 25G needle success and pain scores.⁽¹¹⁾ However, in spite of it (arterial puncture for ABG analysis) remaining one of the most common procedures performed, there is a paucity of studies or clinical audits to assess knowledge and practice about the procedure amongst the healthcare workers who commonly perform it. Our study aims to fill this void and is carried out to reduce errors by identifying areas where implementation of change is needed.

Consent:

Informed verbal consent was taken from all participants.

Inclusion Criteria:

Data was collected from the Trauma and Emergency and Critical Care Units. Interns and Residents performing radial artery punctures for sample collection for ABG analysis were included.

Exclusion Criteria:

Those not willing to participate were excluded from the study.

METHOD

The data collection was done at the above-mentioned areas of our hospital, which is a tertiary teaching hospital attached to a Medical College. Once the need for the study was identified and standards of care defined, a proposal for a Clinical Audit was submitted to the hospital's QI group for permission. Data collection was carried out to assess quality by observing the participants perform the procedure and this was followed up by a questionnaire-based interview to assess the knowledge and attitude. The authors collected data themselves after taking informed verbal consent using a proforma which was made with the help of an existing checklist to mark if all steps were performed correctly during observation.⁽¹²⁾

Findings from both observation and interview were recorded, entered into the proforma, and then into an Excel sheet. Table 1 shows the proforma used to collect data.

Data from educational material in the form of PowerPoint presentations was prepared and presented to the participants. They were observed performing the procedure again after the intervention and findings were rerecorded to see if there was improvement. Subsequently, data analysis was done.

Table 1 : Proforma

S. No Criterion			
A. PROCEDURE SKILL			
		Performed	Not Performed
1	Gather equipment and label the syringe mentioning the patient details and FiO ₂ .		
2	Greeting and Introduction.		
3	Explain the procedure to the patient, obtain consent and ask pre procedure questions.		
4	Perform Modified Allen Test and choose appropriate hand.		
5	Perform hand hygiene, wear gloves and clean the site.		
6	Palpate the radial artery with non-dominant hand close to the planned puncture site.		
7	Warn the patient about needle insertion.		
8	Insert the needle through the skin at the insertion site at an angle of 30-45 degree.		
9	Allow the ABG syringe to self-fill till the required amount of blood has been collected.		
10	Remove the needle and apply immediate firm pressure over the puncture site for 3-5 minutes with some gauze/cotton.		
11	Discard equipment according to biomedical waste management.		
B. KNOWLEDGE/ INTERVIEW			
1	How many times have you performed this procedure?		
2	Was any formal training given to you with regards to this procedure?		
3	Do you know the indications of arterial blood collection in this patient?	Yes	No
4	Are you aware about the Modified Allen Test?	Yes	No
5	Do you know how to perform Modified Allen Test? Demonstration Steps: Ask the patient to clench their fist. Apply pressure over the radial and ulnar artery to occlude both vessels. Ask the patient to open their hand, which should now appear blanched. Remove the pressure from the ulnar artery whilst maintaining pressure over the radial artery. Time how quickly colour returns to the hand.		
6	Are you aware of the importance of performing Modified Allen Test before the procedure?		
7	Are you aware of the indications of the procedure? (Mention at least two)		
8	Are you aware of the complication of the procedure? (Mention at least two)		
9	Are you aware of the contraindications of the procedure? (Mention at least two)		

STATISTICAL ANALYSIS

Descriptive statistics was used to analyze the data. Frequency (%) was calculated and the pre and post-test findings were tabulated for each question with 0 denoted for a

wrong answer and 1 denoted for the right answer or 0 denoted for “no” and 1 for “yes”.

RESULT

Table 2: Experience of the participants

	Number of times procedure performed before (experience)					Total
	<10	11-20	21-30	150	Many times (lost count)	
Interns	3	3	2	0	9	17
PG students				1	3	4
Fellow					1	1
Total	3	3	2	1	13	22

A total of 22 participants were observed and interviewed in Emergency (3) and Critical care units (19). Out of these, 17 were interns, 4 were postgraduate students in Respiratory medicine and 1 was a fellow in

Critical Care Medicine. 11 were male, and 11 were female. The majority had performed the procedure many times earlier and it was noted that none of the participants were novices.

Table 3 : Findings from the interview

Questions	Interns (17)	PG student (4)	Fellow (1)	Total (22)
Was any formal training given to you with regards to this procedure?	0	0	0	0
Do you know the indications of arterial blood collection in this patient?	11	4	1	16
Are you aware about the Modified Allen Test?	10	4	1	15
Do you know how to perform Modified Allen Test? Demonstration of Steps.	6	3	1	10
Are you aware of the importance of performing Modified Allen Test before the procedure?	8	3	1	12
Are you aware of the indications of the procedure?	15	4	1	20
Are you aware of the complication of the procedure?	13	4	1	18
Are you aware of the contraindications of the procedure?	7	4	1	12

None had received formal training. 16 knew the indication for the procedure in the current patient and 6 did not know (all interns). Only 15 (4 PG students, 1 fellow, 10 interns) were aware of Modified Allen's test, and out of these, 12 (3 PG students, 1 fellow, 8 interns) knew the importance of doing it, but only 10 (3 PG students, 1

fellow, 6 interns) knew how to perform it. 2 (both interns) did not know the indications for the procedure in general, 4 (all interns) were not aware of the complications that can occur and 10 (all interns) did not know about the contraindications. Table 3 lists the findings recorded during the interview.

Table 4 : Compliance to steps of the procedure

Steps	Interns (17)	PG student (4)	Fellow (1)	Total (22)
Gather equipment and label the syringe mentioning the patient details and FiO2.	17	4	1	22
Greeting and Introduction	2	1		3
Explain the procedure to the patient, obtain consent and ask pre-procedure questions.	3	4		7
Perform Modified Allen Test and choose appropriate hand.	0	0	0	0
Perform hand hygiene, wear gloves and clean the site.	17	4	1	22
Palpate the radial artery with non-dominant hand close to the planned puncture site.	17	4	1	22
Warn the patient about needle insertion.	3	3		6
Insert the needle through the skin at the insertion site at an angle of 30-45 degree.	17	4	1	22
Allow the ABG syringe to self-fill till the required amount of	17	4	1	22

blood has been collected.				
Remove the needle and apply immediate firm pressure over the puncture site for 3-5 minutes with some gauze/cotton.	7	1	1	9
Discard equipment according to biomedical waste management.	17	2		19

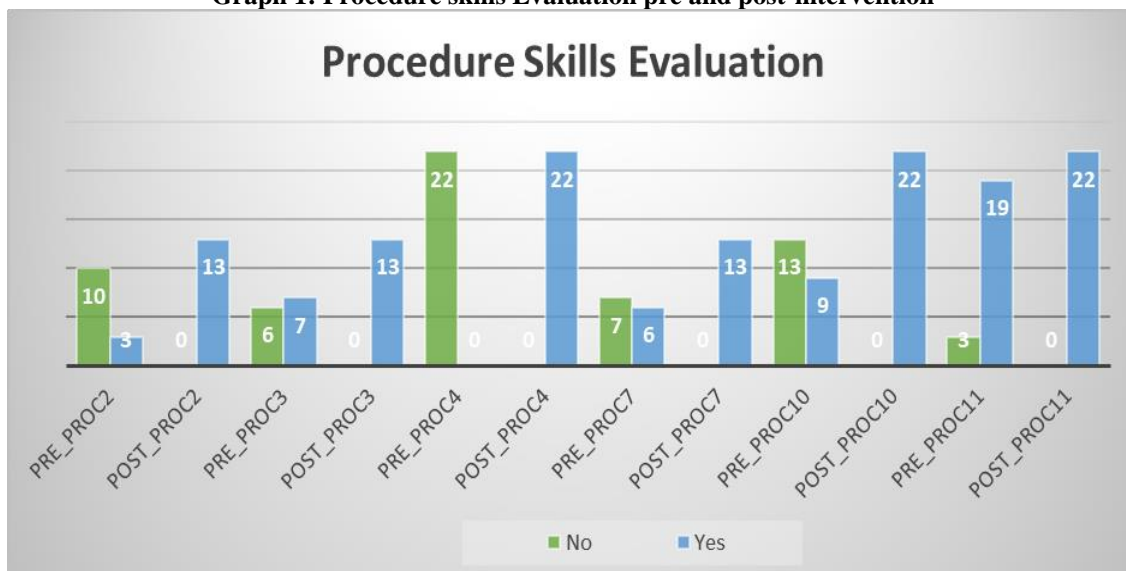
With regards to the procedure skill, while every participant performed the step of gathering the necessary equipment and followed hand hygiene; only 3 greeted the patient, introduced themselves and only 7 explained the procedure to the patient. These steps were not applicable/not possible in 9 procedures due to various factors related to the patient. Not a single participant performed the Modified Allen's test and chose the appropriate hand. All palpated the radial artery correctly with the non-dominant hand close to the site of puncture and inserted the needle at the correct angle allowing the syringe to self-fill, but only 6 warned the patient before puncturing the artery. Only 9 applied firm and immediate pressure at the puncture site with gauze/cotton for 3-5 minutes. 3 did not dispose of the equipment according to the biomedical waste policy.

Based on the above findings, the areas which required change were identified. A PowerPoint presentation was prepared to highlight different aspects under the following headings-

1. About the Audit
2. Indications of ABG
3. Complications of ABG
4. Contraindications of ABG
5. Modified Allen's Test (MAT)
6. Importance of MAT
7. Video of the procedure
8. Equipment needed
9. OSCE steps of the procedure

The participants were encouraged to ask questions and clear doubts if any. They were observed once again while performing the procedure and the findings were recorded.

Graph 1: Procedure skills Evaluation pre and post-intervention

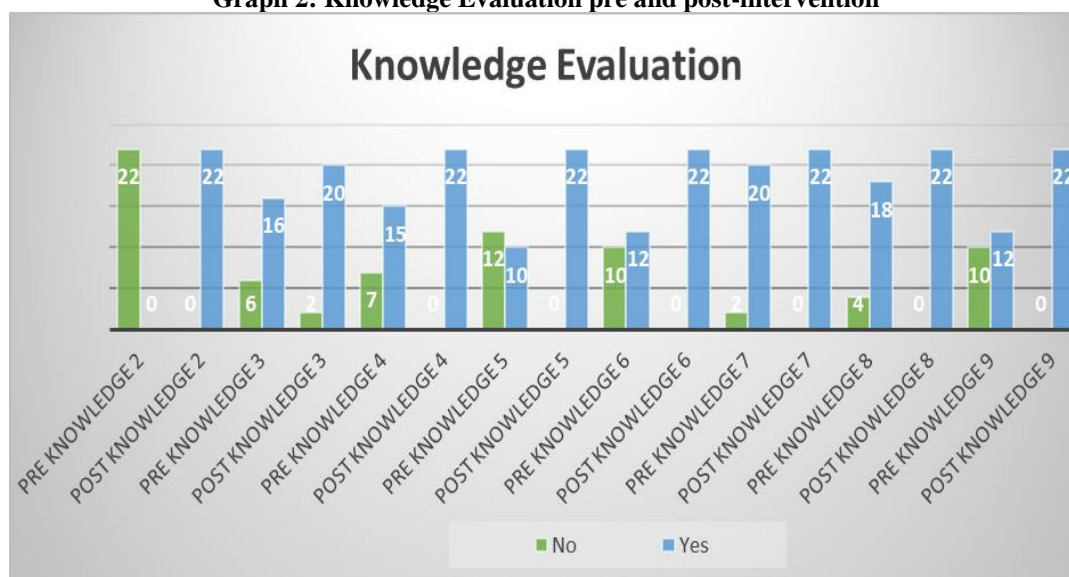


Pre_proc: Initial assessment in accordance with the steps from the proforma.

Post_proc: Reassessment of same steps after PowerPoint presentation.

Note- The sample size is 13 at steps 2, 3, and 7 of the procedure as the patient was unconscious, and hence certain steps were not applicable.

Graph 2: Knowledge Evaluation pre and post-intervention



*Pre knowledge: Initial assessment of knowledge in accordance with proforma
 Post knowledge: Reassessment after PowerPoint presentation*

DISCUSSION

Out of the 22 participants, 77.3 % (17) were interns. None of the participants were new to the procedure and more than 50% had done the procedure many times (uncountable) which highlights how commonly performed the procedure is. None of them had undergone any formal training for the procedure, which reveals that a procedure this important isn't a part of skill training in the routine curriculum.

Only 72.7% (16) knew the indication for the procedure in the current patient and 27.3% (6)(interns) did not know. 68.2% (15) were aware of Modified Allen's test out of which 54.5% (12) knew the importance of doing it, but only 45.5% (10) knew how to perform it which shows that there is a gap between the theoretical knowledge and its application in clinical practice. 9.1% (2)(interns) did not know the indications for the procedure in general, 18.2% (4)(interns) were not aware of the complications that can occur and 45.5% (10)(interns) did not know about the contraindications for the procedure which shows a knowledge gap in this subgroup.

With regards to the procedure skill, while every participant performed the step of gathering the necessary equipment and followed hand hygiene; only 13.6% (3)

greeted the patient, introduced themselves; only 31.8% (7) explained the procedure to the patient and only 27.3% (6) warned the patient before puncturing the artery. This reveals that there is a necessity to reinforce the importance of communication and empathy towards the patient, amongst young medical graduates.

It is important to note that not a single participant performed the Modified Allen's test, a critical step, and prerequisite before puncturing the radial artery. Only 40.9% (9) applied firm and immediate pressure at the puncture site with a gauze/cotton for 3-5 minutes. These two are critical steps of the procedure and not performing them can lead to limb and life-threatening complications. Since this group has not undergone any training and has learned from their seniors, one can assume that these steps weren't stressed enough during the informal training/ not performed by their seniors indicating that the findings in this group may apply to other groups as well. 13.6% (3) (PG students, fellow) did not dispose of the equipment according to the Biomedical waste policy. All interns however disposed of the equipment correctly.

Post-intervention, an overall improvement was noted in the procedural skills with

100% of the participants performing all the steps, especially the two most critical steps, that is, the Modified Allen's Test and applying firm, immediate pressure at the puncture site with a gauze/cotton for 3-5 minutes. Although an improvement was noted in the knowledge of the participants, few of them were still unaware of the indications of ABG highlighting that knowledge gaps exist about this procedure. Training in this procedure is not part of the curriculum, making learning very informal and unstructured, resulting in such gaps in both theory and procedural skills.

The knowledge gaps, absence of empathy, and communication can lead to complications and poor patient experience both of which compromise quality patient care. The need for disposal of Biomedical waste according to the policy should be reinforced, mandatory, and universally followed.

The limitation of our study is the small sample size. More studies with larger and more heterogeneous groups are needed.

CONCLUSION

There is a necessity for awareness and formal training about arterial blood sampling for ABG analysis among young graduates. Similar knowledge gaps may exist with regard to other commonly performed yet important procedures and Clinical audits should be designed around such procedures to help assess the quality, identify deficiencies, and design interventions to implement change. They should be regularly performed in clinical setups to enhance the quality of care.

Declaration by Authors

Ethical Approval: Approved

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Conflict of Interest: The authors declare no conflict of interest.

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