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Original Article

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Clinical Skills Training: Do Medical Students Have Enough Knowledge of Accurate Blood Pressure Measurement When They Graduate*

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ABSTRACT

Objective: Accurate blood pressure measurement is critical for diagnosing and treating hypertension. Our study investigated the medical faculty students' adherence to international blood pressure measurement recommendations.
Methods: Three hundred fifteen final-year medical students from University and due to graduate in 2021 and 2022 were included in the study. These were asked 21 questions evaluating the different blood pressure measurement steps. The responses were then compared with the guideline recommendations.
Results: Of the students, 55.2% were women and 65.7% were 2021 graduates. The majority (69.2%) of the students preferred aneroid devices, while 19.7% selected mercury devices for measurement, and 47.6% paid attention to calibration and validation during device selection. Most participants (92.1%) reported taking measurements sitting, with the back supported and the legs uncrossed. While 62.9% measured blood pressure from both arms at the initial visit, only 37.8% investigated all affecting factors before measurement. Seventy-four percent of the students answered the cuff deflation rate correctly. Approximately half (55.2%) recorded the measured values by rounding them up or down to the nearest even number. Although more than 50% of students answered most of the questions in line with the guidelines, only 1 student completed all the steps appropriately.
Conclusion: The results of this study showed that students did not fully comply with the measurement recommendations. Considering the importance of accurate blood pressure measurement to public health, it would be beneficial to reorganize the medical education curriculum and repeat it regularly.
Keywords: Blood pressure measurement, hypertension, medical students

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INTRODUCTION

Hypertension is a common public health problem; about one-third of adults worldwide are hypertensive. It is the leading modifiable risk factor for mortality and accounted for 10.8 million deaths in 2019.[1] Lowering blood pressure (BP) reduces morbidity and mortality among various baseline BP levels and comorbidities. Recently, large meta-analyses showed that 5- and 10-mm Hg reduction in systolic BP reduced the risk of major cardiovascular events by about 10% and all-cause mortality by 13%.[2,3]

Although home BP measurement and ambulatory BP measurement have recently been described as potentially more accurate in diagnosing hypertension, office blood pressure measurement (OBPM) is still valid and widely employed.

Accurate measurement of BP is essential in the diagnosis and follow-up of hypertensive patients. However, 29 potential sources of inaccuracy in BP measurement have been identified and categorized as either patient, device, procedure, or observer related.[4] Inaccurate BP

measurement can lead to significantly incorrect assessments (under-diagnosis or over-diagnosis of hypertension), which may result in inadequate or unnecessary treatment. Therefore, it is essential to determine whether all healthcare professionals, especially doctors and nurses, accurately measure BP.

This study aimed to determine the BP measurement attitudes of medical students and their level of knowledge concerning accurate BP measurement.

METHODS

Study Population and the Survey

Final-year medical students (known as "intern physicians" in Türkiye) from the Ondokuz Mayıs University Faculty of Medicine in the academic years 2020-2021 and 2021-2022 were included in this study. The study was approved by the Ondokuz Mayıs University Clinical Research Ethics Committee (date: August 18, 2021; protocol number OMU 2021/128) and was conducted under the principles of the Declaration of Helsinki. Twenty-one questions concerning accurate BP measurement were put to the participants through an online structured survey. The questions were produced based on the information contained in the current recommendations for accurate BP measurement. Written informed consent was obtained from the students who participated in this study.

The survey consisted of 4 parts (Table 1). The first questions were about the devices the participants preferred for BP measurement and the factors involved in device selection. The second investigated patient-related factors affecting BP measurement. Participants selected the factors affecting BP from multiple options. The potential options included resting, smoking, or drinking alcohol, using caffeine, whether the bladder is empty, and the patient's arm being completely free of clothing. The third part contained questions concerning procedure-related factors. These were intended to determine the position in which the patient's BP is measured, whether the patient rested before the measurement, and what the patient's back, leg, and arm positions were during the measurement. Questions about the cuff included factors affecting the cuff size selection, its place in the measurement, inflation, and deflation rates. Participants indicated which arm they used to measure BP at the initial visit and the time interval between multiple measurements. The final part determined how the participants recorded the BP values as an observer-related factor.

Statistical Analyses

Descriptive statistics were used throughout the study, and the variables were presented as numbers and percentages. Chi-square tests were used to evaluate students' attitudes during BP measurement according to their anticipated years of graduation. Statistical significance was set at $P < .05$. Data entry and statistical analysis were performed on IBM Statistical Package for the Social Sciences Statistics for Windows version 25 software (IBM SPSS Corp.; Armonk, NY, USA).

RESULTS

Three hundred and fifteen students participated in the study. The majority were women (55.2%) and expected to graduate in 2021 (65.7%). The participants' mean age was 24.83 $\pm$ 1.96 years. The answers given to the survey questions are shown in the Table-1.

Analysis revealed that 69.2% of the participants reported measuring or preferring to measure BP using an aneroid device. While automated devices were the least popular option (11.2%), 19.7% of the participants preferred mercury sphygmomanometers. Asked what factors should be considered when selecting a sphygmomanometer, 47.6% of students were interested in the device's calibration and validation, although 36 (11.4%) paid no attention to both.

Asked which conditions they checked before BP measurement, only 119 (37.8%) participants took into account all the relevant factors (empty bladder, quiet room, comfortable temperature, and avoiding caffeine, exercise, smoking, and alcohol use) set out in the guidelines. Two hundred twenty-five participants (71.4%) reported requiring their patients to rest for at least 5 minutes, while 11 (3.5%) measured BP with no such rest. Asked which position they prefer for BP measurement, all but 3 (0.9%) reported measuring BP with the patient in a sitting position. The majority (92.1%) also ensured that the patient's back should be supported and the legs uncrossed, as stated in the guidelines.

Regarding arm position, more than half (56.8%) of the students responded that "the arm should be supported and at heart level." The correct arm position in a standing or prone position was known by 72.4% and 78.4% of the participants, respectively.

Asked how they selected the cuff size, 42 (13.4%) participants paid no attention to the arm circumference. Two hundred forty-two (76.8%) participants answered "2-3 cm above the antecubital fossa" for the placement of the cuff on the arm, and 63 (20%) responded "5-6 cm above the antecubital fossa." Approximately three-quarters of the participants (76.2% and 74%, respectively) stated that they inflated the cuff to 30-40 mm Hg above

MAIN POINTS

- Accurate blood pressure measurement is essential for diagnosing hypertension.
- Inaccurate blood pressure measurement can lead to incorrect hypertension classification.
- Medical students show poor compliance with recommendations for blood pressure measurement guidelines.
- When the blood pressure measurement steps were examined separately, more than half of the participants generally used these as described in the guidelines. However, only 1 student answered all the questions correctly.

Table 1. The Students' Answers to Questions Concerning Accurate Blood Pressure Measurement

Factors Affecting Accurate Blood Pressure Measurement		n (%)
Device related		
Preferred device	Mercury	62 (19.7)
	Aneroid	218 (69.2)
	Automated	35 (11.1)
Factors affecting device selection	Validated	22 (7)
	Calibrated	107 (34)
	Both validated and calibrated	
	Others	
Patient related		
Conditions affecting accurate BP measurement	All (rest, no exercise, no caffeine and alcohol, room temperature, empty bladder, bare arm, and no smoking)	119 (37.8)
Procedure related		
Resting time before BP measurement	Never rest	11 (3.5)
	2-3 minutes	79 (25.1)
	At least 5 minutes	225 (71.4)
Preferred patient position for BP measurement	Sitting	312 (99.1)
	Standing	3 (0.9)
Patient position in BP measurement when sitting	Back unsupported, legs uncrossed	23 (7.3)
	Back supported, legs uncrossed	290 (92.1)
	Back supported, legs crossed	2 (0.6)
Arm position in BP measurement when sitting	The arm supported and at heart level	179 (56.8)
	The arm unsupported and at heart level	112 (35.6)
	Arm supported and 4 cm above heart level	8 (2.5)
	Arm supported and 4 cm below heart level	14 (4.4)
	Arm unsupported and above heart level	2 (0.6)
Arm position in BP measurement with the patient in a supine position	4 cm above heart level	48 (15.2)
	4 cm below heart level	20 (6.3)
	At heart level	247 (78.4)
Arm position in BP measurement with the patient standing	At heart level	228 (72.4)
	4 cm below heart level	55 (17.5)
	4 cm above heart level	32 (10.2)
Factors in cuff size selection	Arm diameter	273 (86.7)
Cuff location on the arm (where should the lower edge be?)	Below the antecubital fossa	2 (0.6)
	On the antecubital fossa	8 (2.5)
	2-3 cm above the antecubital fossa	242 (76.8)
	5-6 cm above the antecubital fossa	63 (20.1)
Value to which the sphygmomanometer is inflated	Up to 200-250 mm Hg	50 (15.9)
	Above 30-40 mm Hg after radial pulse has disappeared	240 (76.2)
	Above 60-80 mm Hg after radial pulse has disappeared	25 (7.9)

Table 1. The Students' Answers to Questions Concerning Accurate Blood Pressure Measurement (*Continued*)

Factors Affecting Accurate Blood Pressure Measurement		**n (%)**
Sphygmomanometer deflation rate	1 mm Hg/s	27 (8.6)
	2-3 mm Hg/s	233 (74)
	4-6 mm Hg/s	47 (14.9)
	7 mm Hg/s	8 (2.5)
Preferred arm for BP measurement at the initial visit	Right arm	40 (12.7)
	Left arm	63 (20)
	Both left and right arms	198 (62.9)
	Which arm does the patient want me to measure?	13 (4.1)
	Which arm is used less during the day?	1 (0.3)
Number of BP measurements in a visit	1	101 (32.1)
	2	203 (64.4)
	3 or more	11 (3.5)
Time between multiple measurements	1-3 minutes	58 (18.4)
	5-10 minutes	180 (57.1)
	10-15 minutes	43 (13.7)
	15-20 minutes	14 (4.4)
	20-30 minutes	20 (6.3)
BP measurement from the leg	Yes	160 (50.8)
	No	155 (49.2)
In which patients do you measure BP from the leg?	All patients at the first visit	11 (3.5)
	Patients with pulse differences	135 (42.9)
	Diabetic patients	3 (1)
BP measurement in a standing position	Yes	150 (47.6)
	No	165 (52.4)
In which patients do you measure BP in a standing position?	All patients at the first visit	66 (21)
	Elderly patients	11 (3.5)
	Diabetic patients	11 (3.5)
	Symptomatic patients	57 (18.1)
Observer related		
Recording of BP measurement values	Rounding to 0- and 5-mm Hg	110 (34.9)
	Rounding to the nearest even number	174 (55.2)
	I record it as "cm Hg"	31 (9.8)

BP, blood pressure.

the level at which the radial pulse disappeared and deflated it at a rate of 2-3 mmHg/s. Asked how they recorded the measurements, 174 (55.2%) participants recorded them to the nearest even number, while 110 (34.9%) rounded them up or down to 0- or 5-mm Hg.

One hundred ninety-eight (62.9%) participants emphasized the importance of taking measurements from both arms at the initial visit. One hundred one (32.1%) students reported taking 1 measurement during the initial evaluation, 203 (64.4%) reported 2, and only 11 (3.5%) reported 3 or more. In addition, 18.4% of the participants reported taking measurements at 1- to 3-minute intervals and 57.1% at 5- to 10-minute intervals.

More than 50% of the students answered most questions correctly (Table 1). However, only 1 correctly answered all the

steps involved in BP measurement. Differences were observed between the groups according to years of graduation (in 2021 or 2022) in 3 questions: (i) the patient's arm position while sitting (61.4% vs. 48.1%; *P* = .025); (ii) the value to which the device is inflated (68.5% vs. 51.2%; *P* = .003); and (iii) consideration of the arm diameter when selecting the cuff size (83.1% vs. 93.5%; *P* = .01), respectively.

DISCUSSION

Blood pressure measurement training is actively given to medical students in their third and fourth years at our university. However, due to the coronavirus disease 2019 (COVID-19) pandemic, we could not provide adequate face-to-face education for fourth-year students graduating in 2022.

This study evaluated medical students' approaches to BP measurement and their levels of knowledge about accurate BP measurement as well as the effect of the COVID-19 pandemic face-to-face education restrictions.

The students exhibited low compliance with the BP measurement methods recommended in the guidelines. When we examined the BP measurement steps separately, more than half of the participants generally applied these as described in the guidelines. However, only 1 student answered all the questions correctly.

Diagnosis of hypertension requires accurate BP measurement. Although the guidelines recommend using automated devices for OBPM, most participants (69.2%) in the present study preferred aneroid devices for OBPM. Automatic devices were less popular (10%). Aneroid devices may result in measurement errors, although regularly calibrated devices can be used safely.[5,6] The fact that our university medical students are mostly trained with aneroid devices may have affected the device selection. Aneroid devices are also frequently used in daily practice. Similarly, a recently published study from Türkiye reported that primary care physicians most frequently use aneroid devices, while automated devices are least often employed in daily practice.[7]

Selecting inappropriate devices is one of the common errors in BP measurement. The importance of validation and calibration of devices is discussed in almost all BP diagnosis and treatment guidelines.[8,9] Uncalibrated devices cause inaccurate BP readings.[10] Akpolat et al[11] reported a higher frequency of accurate devices among validated than in non-validated sphygmomanometers and that online websites where validation status can be checked are easily available.[9] Half of the participants in the present study paid attention to validation and calibration, while approximately 10% disregarded these.

Proper maintenance and routine calibration of BP equipment are crucial to the accuracy of BP readings.[12] A study of physician practices in Switzerland reported that 97% of devices had not been calibrated for at least 2 years. More importantly, the number of sphygmomanometers with measurement errors increased significantly 2 years after maintenance.[13]

Less than half of the medical students in this study investigated all factors capable of affecting BP before taking measurements, and three-quarters reported that the patient should rest for at least 5 minutes. In a study involving 103 fourth-year medical students in Iran, only a few (13.6-50.5%) participants discussed the situation with the patient before measurement, and only 31.1% required the patient to rest for 5 minutes.[14] Rates of investigation of factors affecting BP measurement in survey studies with medical students range between 54% and 97%.[15-17] However, some parameters, such as bladder distension, are frequently entirely forgotten.[18] In other studies, most medical students (54%-86.3%) have been shown to know that they should require patients to rest for at least 5 minutes.[14-16] The awareness rate in the present research was higher than that in a study largely composed of cardiologists[19] but lower than that observed among family physicians in Türkiye.[7]

Most of the students in this study knew that BP measurement should be performed with the patient in a sitting position, that the patient's back should be supported, and that the legs should not be crossed. Studies have shown that a non-optimal arm position during BP measurement results in higher systolic and diastolic BP values,[20] and the guidelines recommend supporting the arm during measurement to obtain correct BP values.[8,9] However, only half of the medical students possessed accurate information concerning arm position in this study.

Cuff size selection is another critical step that affects BP measurement. The inflatable bladder of the cuff must cover 75%-100% of the individual's arm circumference. However, 13.4 % of the participants in this study disregarded the cuff size. While results similar to those of this study have been reported,[16] some studies have reported that medical students attach no importance to the selection of cuff length.[15,16] Three-quarters of the students in this research gave answers compatible with the guidelines concerning arm cuffing, inflation point, and inflation rate. These factors are well known to affect accurate BP measurement.

All guidelines[8,9] recommend recording BP measurements rounded to the nearest even number. However, despite an improvement in recent years, 40% of BP measurements in the USA are rounded to zero.[21] The incidence of a final digit of zero for BP is approximately 35% in both Canada and the UK.[22] A similar rate of 35% was observed in this study. However, only 21.4% of primary care physicians in Türkiye are reported to record measurements to the nearest even number.[7] Gozdecki et al[23] showed that standardized oscillatory BP measurement implementation reduced the terminal digit preference.

Administration of Automated office blood pressure (AOBP) has also been associated with decreased end-digit preference levels in clinical practice.[22]

Approximately two-thirds of the participants measured BP from both arms at the first visit and took at least 2 measurements. Only 18.4% cited an interval between measurements of 1-3 minutes, the most common being 5-10 minutes. However, these measurement errors are also quite common in clinical practice.[7,19]

More than half of the students provided answers in accordance with the guidelines for each question concerning the steps involved in BP measurement in this study. However, only 1 answered all the questions correctly. While this is somewhat surprising, Rakotz et al[17] also reported that only 1 out of 159 medical students demonstrated proficiency in all BP skills. The students' performances in that study were generally poor. In a well-designed study, Ulusoy et al[24] observed that physicians did not fully comply with guideline recommendations and had many errors during BP measurement. But even more strikingly, they reported 39 (46.4%) out of the 84 physicians never measured BP during patient examinations. The researchers determined that 18.9% of patients whose BP was not measured were hypertensive.

The COVID-19 pandemic also affected medical education. Although most of the results in this study were not affected by face-to-face or online education, differences were observed in 3 different steps. Some studies have suggested that online education was sufficient during the pandemic.[25] Similarly, although their data showed that simulation-based BP measurement training also yields successful results[26], Basheer et al[27] reported that medical students who trained on their colleagues (conventional training) exhibited a higher rate of accurate BP recording than those who received simulation-based training. Skill development is generally reinforced by training, practice, and repetition. Accurate BP measurement rates among medical students improve with training, and increasing the duration and intensity of education improves proper BP measurement skills.[28]

This study has several limitations. First, this research was a survey study. The participants' responses do not reflect the general population and may cause bias. The answers given to surveys and approaches to measurement may not reflect the situation in clinical practice. In addition, it is impossible to establish a cause–effect relationship in survey studies. However, surveys should be carried out intermittently to evaluate knowledge levels and rearrange training accordingly. A particular strength of this study is that it included many medical students who would soon be involved in diagnosing and treating real-life hypertension.

The results of this study indicate that compliance with appropriate BP measurement techniques among medical students is low. Reviewing and adjusting the curriculum and intensifying and repeating training at regular intervals may increase the rate of accurate BP measurement.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Ondokuz Mayıs University (Date: August 18, 2021; Number: OMU 2021/128).

Informed Consent: Written informed consent was obtained from the students who participated in this study.

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REFERENCES

1. GBD 2019 Risk Factors Collaborators. Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet*. 2019; 396:1223-1249.
2. Blood Pressure Lowering Treatment Trialists' Collaboration. Pharmacological blood pressure lowering for primary and secondary prevention of cardiovascular disease across different levels of blood pressure: an individual participant-level data meta-analysis. *Lancet*. 2021;397(10285):1625-1636. [CrossRef]
3. Ettehad D, Emdin CA, Kiran A, et al. Blood pressure lowering for prevention of cardiovascular disease and death: a systematic review and meta-analysis. *Lancet*. 2016;387(10022):957-967. [CrossRef]
4. Kallioinen N, Hill A, Horswill MS, Ward HE, Watson MO. Sources of inaccuracy in the measurement of adult patients' resting blood pressure in clinical settings: a systematic review. *J Hypertens*. 2017;35(3):421-441. [CrossRef]
5. Waugh JJ, Gupta M, Rushbrook J, Halligan A, Shennan AH. Hidden errors of aneroid sphygmomanometers. *Blood Press Monit*. 2002; 7(6):309-312. [CrossRef]
6. Farhan K, Naqvi STS, Rizvi SAH, Zafar A, Rawala MS. Comparison between blood pressure readings using a mercury versus an aneroid sphygmomanometer. *Blood Press Monit*. 2020;25(1):34-38. [CrossRef]
7. Kirhan İ, Kir S, Dilek M. Self-reported practices of doctors and nurses for the measurement of blood pressure. *Blood Press Monit*. 2021;26(1):8-13. [CrossRef]
8. Rabi DM, McBrien KA, Sapir-Pichhadze R, et al. Hypertension Canada's 2020 comprehensive guidelines for the prevention, diagnosis, risk assessment, and treatment of hypertension in adults and children. *Can J Cardiol*. 2020;36(5):596-624. [CrossRef]
9. Stergiou GS, Palatini P, Parati G, et al. 2021 European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement. *J Hypertens*. 2021;39(7):1293-1302. [CrossRef]

10. Turner MJ, Speechly C, Bignell N. Sphygmomanometer calibration – why, how and how often? *Aust Fam Phys*. 2007;36(10):834-838.
11. Akpolat T, Dilek M, Aydogdu T, Adibelli Z, Erdem DG, Erdem E. Home sphygmomanometers: validation versus accuracy. *Blood Press Monit*. 2009;14(1):26-31. [CrossRef]
12. Arena SK, Bacyinski A, Simon L, Peterson EL. Aneroid blood pressure manometer calibration rates of devices used in home health. *Home Healthc Now*. 2016;34(1):23-28. [CrossRef]
13. Zuber M, Schäfer HH, Kaiser W, Erne P. Measuring accuracy of sphygmomanometers in the medical practices of Swiss primary care physicians. *Eur J Gen Pract*. 2013;19(4):244-247. [CrossRef]
14. Pezeshki MZ, Moghaddas F, Ghaffari S. Educational intervention improves measurement of blood pressure skills in Iranian medical students. *Res Dev Med Educ*. 2019;8(2):80-84. [CrossRef]
15. González-López JJ, Gómez-Arnau Ramírez J, Torremocha García R, Albelda Esteban S, Alió del Barrio J, Rodríguez-Artalejo F. Knowledge of correct blood pressure measurement procedures among medical and nursing students. *Rev Esp Cardiol*. 2009;62(5):568-571. [CrossRef]
16. Gazibara T, Rancic B, Maric G, Radovanovic S, Kisic-Tepavcevic D, Pekmezovic T. Medical students, do you know how to measure blood pressure correctly? *Blood Press Monit*. 2015;20(1):27-31. [CrossRef]
17. Rakotz MK, Townsend RR, Yang J, et al. Medical students and measuring blood pressure: results from the American Medical Association Blood Pressure Check Challenge. *J Clin Hypertens (Greenwich)*. 2017;19(6):614-619. [CrossRef]
18. Ghareeb S, Youssef G, Ghareeb HS, et al. Results of a project to calibrate mercury sphygmomanometer blood pressure-measuring devices in Egypt. *J Hum Hypertens*. 2021;35(10):921-926. [CrossRef]
19. Gulati M, Peterson LA, Mihailidou A. Assessment of blood pressure skills and belief in clinical readings. *Am J Prev Cardiol*. 2021;8:100280. [CrossRef]
20. Netea RT, Lenders JW, Smits P, Thien T. Both body and arm position significantly influence blood pressure measurement. *J Hum Hypertens*. 2003;17(7):459-462. [CrossRef]
21. Foti KE, Appel LJ, Matsushita K, Coresh J, Alexander GC, Selvin E. Digit preference in office blood pressure measurements, United States 2015-2019. *Am J Hypertens*. 2021;34(5):521-530. [CrossRef]
22. Greiver M, Kalia S, Voruganti T, et al. Trends in end digit preference for blood pressure and associations with cardiovascular outcomes in Canadian and UK primary care: a retrospective observational study. *BMJ, (Open)*. 2019;9(1):e024970. [CrossRef]
23. Gozdecki L, Kramer H, Thomas M, et al. Protocol to improve hypertension management in a VA outpatient clinic. *J Hum Hypertens*. 2023;37(1):50-55. [CrossRef]
24. Ulusoy Ş, Özkan G, Güvercin B, Sökmen Y, Erdem Y. Do physicians measure patients' blood pressure, and are those measurements reliable? *J Hum Hypertens*. 2018;32(3):203-211. [CrossRef]
25. Kronenfeld JP, Ryon EL, Kronenfeld DS, et al. Medical student education during COVID-19: electronic education does not decrease examination scores. *Am Surg*. 2021;87(12):1946-1952. [CrossRef]
26. Yamazaki Y, Hiyamizu I, Joyner K, Otaki J, Abe Y. Assessment of blood pressure measurement skills in second-year medical students after ongoing simulation-based education and practice. *Med Educ Online*. 2021;26(1):1841982. [CrossRef]
27. Basheer A, Das S, Iqbal N, Kandasamy R. Simulation-based training in measurement of blood pressure: a randomized study of impact in real-life settings. *Simul Healthc*. 2019;14(5):293-299. [CrossRef]
28. Holmstrup M, Jensen B, Burkart R, Levis M. Using a novel assessment of procedural proficiency provides medical educators insight into blood pressure measurement. *Int J Med Educ*. 2016;7:375-381. [CrossRef]