Blood pressure measurement: A worthy technique for nurses!

By Céline Plante, RN, MSc, Professor of Critical Care (Emergency), Université du Québec à Rimouski - campus de Lévis, Québec

Those unfamiliar with the health field and, unfortunately, many health professionals consider blood pressure (BP) measurement a triviality. It is understandable that those "delegated" health procedures and techniques, which contribute to saving patients' lives, lead to greater professional gratification than the measuring of BP. However, the results obtained trigger a multitude of acts and prescriptions that are not without consequence. Buus-Frank (2003) advises nursing personnel neither to underestimate themselves because they don't believe they perform vital health care functions, nor to limit themselves because they have too few letters after their names. BP monitoring is a complex, everyday technique that shouldn't be "swept under the rug" because it is considered a routine procedure (Costan, 2003).

Imagine a situation in which your electronic sphygmomanometer displays a result of 180/124. Surprised by this result, you retake the BP, this time with a manual device, and obtain a very different result. Which device is the most reliable? The answer to this question involves many scientific, physiological and technical dimensions as described in the following pages. This article reviews the basic principles of an efficient BP measurement – a review that may surprise some readers.

Vital parameter

In an era in which medical technology abounds and research explores myriad pathways, it is ironic that BP monitoring is still the most effective indicator of life expectancy. BP is, in fact, an early indicator for a diversity of pathologies, many of which are fatal or have high death rates. These include diseases of different systems such as cardiovascular (left ventricular dysfunction and hypertrophy, cardiac insufficiency, angina, myocardial infarction), cerebral (stroke, transient ischemic attack), renal (chronic renal insufficiency), ocular (retinopathy) and peripheral vascular (Buss-Frank, 2003). Taking the BP seems a simple task, yet it is one of great medical importance. The consequences are diverse. A rise in BP may be the first sign of an underlying condition or primary hypertension. Without a regular, systematical measurement, no detection is possible before other symptoms or signs appear. Without follow-up or treatment, the problem eventually progresses and becomes more complicated. A man with untreated hypertension loses approximately one year of life expectancy per mmHg increase in his diastolic blood pressure (DPB) (NHLBI and AHA, 2002). "That's why all medical associations tend to tighten up the BP values that are said to be normal or optimal"(Daniels, 2004). BP monitoring is, therefore, the foundation for decisions affecting changes in lifestyle and drug prescriptions for common as well as acute conditions.

Precision is crucial

Since BP is a vital sign, the measurement should not be performed in a nonchalant manner. Nevertheless, many people assume an underestimation of 5 mmHg is insignificant and without important consequence. Yet, one such error at the 90-95 mmHg range would miss over 21 million Americans afflicted with diastolic hypertension. Out of this number, 125,000 will die from coronary artery disease within the following six years, a mistake loaded with consequences since 20% of these deaths and a similar number of fatal strokes could have been prevented with an anti-hypertensive therapy. If we use the previous example again, but this time the error is in an overestimation, 27 million Americans would be incorrectly classified as hypertensive, with all the implications such a diagnosis involves (i.e., monetary expenses and unnecessary medical side effects) (NHLBI and AHA, 2002).

When we take into account all of these potential clinical and monetary consequences, we more easily understand that this fundamental process should be taken seriously and executed with rigour, caution and precision. This is why diverse health organizations, associations and societies regularly issue recommendations for conditions and techniques to measure BP. These recommendations concern all the potential sources of imprecision, whether it is the method used, the professional, the patient or the procedure.

Method used

BP can be measured directly or indirectly, the golden standard being the direct form. Arterial cannulation is the only form of measurement that permits the determining of pressure within the arteries. Since it is an invasive and costly technique with possible complications such as infection and blood clotting, it cannot be carried out on a large scale. The indirect measure is both more common and non-invasive. This form consists of

compressing an artery under the soft tissues with an inflatable cuff. Contrary to the direct form, it is the counter-pressure in the artery that is measured as opposed to the pressure, hence the less reliable result (Mialon, 2003). Indirect monitoring, if done correctly, is usually within 10 mmHg of direct measurement.

BP is most often measured indirectly by one of the three following methods: oscillometric, auscultatory (mercury or aneroid devices) or by palpation. Knowing the limits of the method used is a key to reducing the number of erroneous results. This is why we will briefly examine them.

Palpation

The palpation method relies on the pulse, usually radial, instead of the arterial sounds. The radial pulse reappearance, when the cuff is deflated, coincides with the estimated systolic blood pressure (SBP): a result of limited precision. The clinical usefulness of this method is then very limited, especially because the DBP can't be monitored.

Auscultation

The auscultation method is used most frequently. We find it in certain automatic and manual devices. As the compressed artery is decompressed, the pulsations give off certain characteristic sounds called Korotkoff (named after the person who first described them). These sounds, either heard through a stethoscope or recorded by a microphone built into certain automatic devices, are separated into five phases. According to the clinical context, the DBP can be either the number obtained in phase IV or in phase V. After reading the following section, you will realize that only a human, a professional, can tell the difference.

Phase I begins with the first of two consecutive sounds and the value accorded to this first sound corresponds to the SBP. Phase II comprises softened sounds that acquire a swishing quality. Phase III comes with the disappearance of the swishing quality of the sounds. They become clearer, sharper and their intensity exceeds that of Phase I. The clinical significance, if any, to Phases II and III has not been established. When the intensity of the sounds suddenly diminishes and a distinct abrupt muffling is heard, Phase IV has been reached. Phase V begins immediately after the last sound has been heard (first silence). This most often defines the DBP. In the right conditions, the SBP measured by the auscultation method corresponds perfectly to the results obtained from a direct measurement. The DBP is about 2 mmHg higher than the intra-arterial DBP.

What result would you indicate with the following example? (Answer on page 37)

Phase I – 138 mmHg: 1st sound; 130: 2nd sound; 128: 3rd sound
Phase II – 120 mmHg: 1st swishing sound (i.e. sound followed by a murmur)
Auscultatory gap (not always present but can't be predicted)
116 mmHg: cessation of sound
108 mmHg: return of swishing sounds
Phase III 104 mmHg: 1st clearer sound with higher intensity and no more swishing
Phase IV 94 mmHg: 1st sound muffled
Phase V 82 mmHg: 1st silence

Nevertheless, certain limitations of the auscultatory method need to be made clear. It is possible that the sounds between Phases II and III disappear momentarily due to physiological or other factors. This phenomenon, called "auscultatory gap", can lead to the risk of underestimation of the SBP and/or overestimation of the DBP if the inflation of the cuff is not heeded. Knowledge of this phenomenon helps avoid the problems it causes if the BP is manually monitored. It is an otherwise unavoidable problem by automated devices. In the case of a child under 13 years of age, or of a difference of 10 mmHg and higher between the first muffled sound (Phase IV) and the first silence (Phase V), the diastolic imprecision rises. It is in order to minimize this imprecision that the DBP in such cases would be the first muffled sound of the Phase IV and the result would then need to be recorded in a three-digit number: Phases I / IV – V or I / IV / V. The situation is the same when the arterial sounds continue to 0 mmHg. Again in this situation, only a manual monitoring can avoid this error. Why? Because, to date, no auscultatory device is programmed to consider these "details". The machine only records the first and last sounds heard (Tavarese, 2003; Lebel, 2004).

If you are not familiar with the aforementioned notions, the Korotkoff sounds, then the accuracy of your auscultatory method will be affected. The reading of literature such as **Guide Thérapeutique de la Société québecoise d'HTA8** or Poggi's article (Poggi, Vaïsse, Silhol, & Bouchlaghem, 2000) is recommended in order to further your knowledge on this subject.

Another source which affects the reliability of the auscultatory method is an irregular cardiac rhythm such as atrial fibrillation (AF). The intensity of the sounds in Phase I being diverse in such cases, determination of the SBP becomes less precise (Poggi, Vaïsse, Silhol, & Bouchlaghem, 2000). If the limitations already listed seem impossible to overcome in the context of your work, the use of a method other than the auscultation should be considered.

Oscillometry

The oscillometric method is found in many automatic devices. It is based on the observation of oscillations recorded by the cuff during deflation. These oscillations begin before the real SBP value and continue beyond the real DBP value, but the maximum intensification of the oscillations compares to the mean blood pressure (MBP). The MBP is the geometrical/graphical average of the SBP as well as the DBP and determines the perfusion of an organ. Since the MBP is neither the most used nor the most familiar parameter in medicine, it is necessary for electronic devices to use automatic calculation methods (algorithms) in order to calculate the SBP and DBP. Unfortunately, these algorithms vary between brands and even between devices. It then becomes arduous to judge the

reliability of such results. Since algorithms are subject to manufacturers' secrecy, it is difficult to validate the results attained in comparison with the gold standard (Jones, Appel, Sheps, Rocella, & Lenfant, 2003; Tholl, Forstner, & Anlauf, 2004). To be recommendable, the precision of a sphygmomanometer must be first evaluated by an independent method that follows the protocols of both the British Hypertension Society (BHS) and the Association for the Advancement of Medical Instrumentation (AAMI). Since there is no legal obligation forcing manufacturers to subject their equipment to independent validations, only a fraction of the electronic devises used around the world are evaluated. The majority of these devices have been proven imprecise (Stergiou, Vousa, Achimastos, & Mountokalakis, 1997; O'Brien, Waeber, Parati, Staessen, & Myers, 2001). The list of recommended or non-recommended devices is constantly updated on the two following websites: bmj.com and bhsoc.org. It is disturbing to see the number of invalid sphygmomanometers found in our health establishments. Despite high numbers of reports of imprecision, the Dinamap 8100 (Critikon, Tampa, FL), for example, remains the most used automatic device in health care centres. It would seem that what the manufacturers have to say about the imprecision of their instruments is more important to the buyers than what the BHS and AAMI standards demonstrate (O'Brien, Waeber, Parati, Staessen, & Myers, 2001).

The use of a valid sphygmomanometer (manual or automatic) does not obviate the need for proper maintenance and an annual calibration (Poggi, Vaïsse, Silhol, & Bouchlaghem, 2000; Tholl, Forstner, & Anluaf, 2004; Graves, 1999). The mechanism of a sphygmomanometer is sensitive and is therefore subject to damage by impact or shock. These forces, as well as regular everyday use, can lead to inaccurate results in BP measurements. The development of a new mechanism, called "Gear Free" by the company Welch Allyn (W/A) could reduce the susceptibility to impact. Time will tell if this new line of manual sphygmomanometers called Durashock stands up to its words.

The lack of a maintenance register for the sphygmomanometers, or of a person responsible for the regular verification of the calibration, calls into question the reliability of the results. Marshall and Rouse (2001) state that health professionals using inaccurate sphygmomanometers are not fulfilling their professional duty and are acting in a non-ethical way. These professionals could be sued for negligence by patients who believe that the use of these malfunctioning devices had bad consequences for their health. A maintenance check-up or calibration should be performed at the first sign of malfunction. Would you be able to detect a few? For example, a device incapable of generating a pressure of 30 mmHg higher than the SBP and incapable of doing this in less than five seconds, or a device that has trouble maintaining this pressure for five seconds (Buus-Frank, 2003) after inflation, suggests an air leak (Poggi, Vaïsse, Silhol & Bouchlaghem, 2000; Graves, 1999). The incapability of obtaining a slow and regular decompression of approximately 2 mmHg per second or per heart beat reflects a faulty permeability in the air release (Poggi, Vaïsse, Silhol & Bouchlaghem, 2000). Fissures in the hand pump or in the tubes, a tube minimal length not respected, plush on the Velcro of the cuff, a needle that does not start out pointing at 0 mmHg or wavers when the glass is flicked are other signs that the precision of the final results is questionable (Beevers, Lip & O'Brien, 2001).

Which indirect method should then be used to diagnose hypertension in the health domain? Until recently, the answer would have been the mercury sphygmomanometer, but prohibition in many countries will cause this method to disappear on the short term (Jones, Appel, Sheps, Rocella & Lenfant, 2003; Tholl, Forstner & Anlauf, 2004; Pickering, 2002). The choice device is then a well-calibrated manual aneroid device (Pickering). Automatic devices can therefore be used for follow-up and when the Korotokoff sounds cannot be adequately evaluated, manual monitoring can be used (Pickering). Among the list of automatic devices, it would seem that the ones using the oscillometric method might be slightly more precise (Lehmann, Gelman, Weber & Lafrades, 1998).

Professional/patient

At this point in your reading, you know that an efficient BP measurement requires the professional to be familiar with certain scientific knowledge. The professional also needs to have certain manual skills and good hearing in order to use a stethoscope for the auscultation method.

As far as the patient is concerned, very little is required in an acute or unstable situation. Nevertheless, a few conditions must be respected in a follow-up. The patient should not have eaten or smoked (+6/+5), nor have consumed alcohol (+8/+8), caffeine (+11/+5) or adrenergic substances an hour prior to the test. The patient should not have done any intense physical exercise in the two hours previous to the exam; the patient should not have any vesical or intestinal urge (+15/+10) and should not speak (+7/+8) during the monitoring. Does this seem exaggerated? The numbers in brackets are possible overestimations in the results for the SBP and DBP if the guidelines are not respected. Therefore, a patient who speaks or hums during the monitoring may receive an overestimation in his SBP of 7 mmHg and an overestimation of 8 mmHg in his DBP!

Procedure

Research has repeatedly shown that BP is rarely measured according to the recommendations of the World Health Organization (WHO) and other professional organizations and this, in turn, affects the precision of the results obtained. The following is a list of their recommendations valid for manual or automatic measurement. The numbers in brackets demonstrate the possible margin of error if the recommendation is not followed. Therefore, a patient seated improperly could have a SBP result overestimated by 6 to 10 mmHg while his DBP would not be affected.

If you do not grasp the theoretical concepts behind these recommended techniques and/or you are not comfortable with

the required skills, the precision of your BP results, manual or automatic, will be affected. A deepening of your understanding and knowledge is recommended.

- Patient seated (+6 to +10/)
- Feet supported and uncrossed (+8/ +4)
- Arms free of constrictive clothing, supported (/+10%) with the anticubital fossa at the level of the fourth inter-costal space (each centimetre away from this level represents a mmHg error)
- Using a proper size cuff, firmly adjusted at 2 to 3 cm above the anticubital fossa: the width of the bladder should cover at least 40% of the arm circumference and its length between 60% and 100% (a cuff that is too loose or too small overestimates the BP whereas one that is too large will underestimate the reading)
- Palpation of the pulse on the arm being measured for BP is done to ensure the pulse regularity and to determine the estimated SBP (rapid inflation prevents venous congestion and imprecision)
- Inflate to 30 mmHg above the estimated SBP (to avoid auscultatory gap)* with the bell of the stethoscope placed on an artery below the cuff, at the distal end of the limb (the bell of a quality stethoscope permits better perception of the Korotkoff sounds than the diaphragm)(* Impossible with certain automatic devices)
- Deflate at a rate of 2 mmHg per second or with each heart beat (a more rapid rate will overestimate the DBP or underestimate the SBP)
- Measurement of the BP in both arms is required if being taken for the first time; a difference between readings will require that the BP be taken in the arm with the higher reading (to avoid missing a hypertension)
- A delay of one minute should be respected before retaking a reading on the same arm in order to avoid any imprecision

Conclusion

Far from having covered everything that concerns BP monitoring, this article nonetheless examined two major aspects: BP results have vital implications, and the accuracy of these results requires some scientific knowledge. Nurses performing simple or complicated procedures must maintain their competences. If there is a doubt concerning the best way to approach a patient, a care technique, the use of a device or its reliability, it's extremely important to raise the issue with a supervisor. Ethics, professionalism and the best interests of the patient are at stake.

As Goodwin (1995) puts it, sophisticated investigative methods still require clinical ability from health professionals. They must know how to interpret the results produced by the devices used and be aware of their limitations. Uncritical reliance on values obtained by machines can be dangerous. The problem is urgent because even though the technology develops, the basic abilities and knowledge are still required… and re-appropriating the basic once forgotten, seems difficult.

Answer: 130 / 94 – 82 or 130 / 94 / 82

130: corresponds to the SBP, in other words is the first of two consecutive sounds, i.e. separated by 2 mmHg (138 is an artefact, i.e. an interference sound, secondary to an extra-systole or other).

94: corresponds to the DBP since there is a difference of more than 10 mmHg between the IV and V phases.

82: corresponds to phase V which must be documented by agreement*.

*Note that you would have missed a grade 1 hypertension if you utilized the phase V (82) rather than IV (92) as the result for the DBP.

The result obtained with a valid automatic auscultatory device would have been 138 / 84 since only the first and last sounds would have been registered: imprecision with the systolic and the diastolic BP and a missed grade 1 hypertension.

References

American Society of Hypertension. (1992). Recommendations for routine blood pressure measurement by indirect cuff sphygmomanometry. **Am J Hypertens, 5**(4), 207.

Beevers, G., Lip, G.Y.H. & O'Brien, E. (2001). ABC of hypertension: blood pressure measurement. **BMJ, 322**, 1043-1047.

Buus-Frank, M.E. (2003). Not just a nurse. **Advances in Neonatal Care, 3**(3), 103-104.

Campbell, N.R., Myers, M.G., & McKay, D.W. (1999). Is usual measurement of blood pressure meaningful? **Blood pressure monitoring, 4**(2), 71-76.

Canadian Hypertension Society. (2004). The 2004 Canadian Hypertension Education Program recommendations for the management of hypertension: Part I – blood pressure measurement, diagnosis and assessment of risk. **Can J Cardiology, 20**(1), 31-40.

Carney, S.L., Gillies, A.H.B., Green, S.L., Patterson, O., Taylor, M.S., & Smith, A.J. (1999). Hospital blood pressure measurement: staff and device assessment**. J. Qua. Clin. Practice, 19**, 95-98.

Costan, G. (2003). Les hauts et les bas de la tension artérielle. **L'actualité médicale**, **10**, pp. 22-33

Daniels, J.G. (2004). Énoncé du Chef de médecine générale, Centre de santé de la MRC d'Asbestos.

Goodwin, J. (1995). The importance of clinical skills. **BML, 310**, 1281-1282.

Graves, J.W. (1999). The clinical utility of out-of-office self-measure blood pressure. **Home Health Care Consultant, 6**(11), 26-29.

Grim, C.M., Grim, C.E., & Drew, C.R. (1995). Teaching and assessing blood pressure measurement skills for medical students. **AJH, 8**(4), part 2.

Gury, C. (2003). Mesure de la pression artérielle: recommandations de bonnes pratiques. **Neurologies, 6**, pp. 536-540.

Jones, D.W., Appel, L.J., Sheps, S.G., Rocella, E.J. & Lenfant, C. (2003). Measuring blood pressure accurately: New and persistent challenges. **JAMA, 289**(8), 1027-1030.

Lebel, M. (2004). Énoncé du président de la Société québécoise d'hypertension artérielle (SQHA).

Lehmann, K.G., Gelman, J.A., Weber, M.A., & Lafrades, A. (1998). Comparative accuracy of three automated techniques in the noninvasive estimation of central blood pressure in men. **Am J Cardiol, 81**(8), 1004-1012.

Marshall, T., & Rouse, A. (2001). Letters: Doctors who cannot calibrate sphygmomanometers should stop taking blood pressures. **BMJ, 323**, 805.

Mialon, P. (2003). **Notes du Cours de physiologie cardiovasculaire, DCEM I**. Faculté de médecine de Brest.

National Heart, Lung, and Blood Institute (NHLBI) and American Heart Association (AHA). (2002). **Summary Report: National High blood Pressure Education Program (NHBPEP)/National Heart, Lung, and Blood Institute (NHLBI) and American Heart Association (AHA).** Working meeting on blood pressure measurement. Natcher Conference Center, National Institutes of Health (NIH), Bethesda, Maryland, April 19, 2002, p. 7.

O'Brien, E., Waeber, B., Parati, G., Staessen, J., & Myers, G. (2001). Blood pressure measuring devices: Recommendations of the European Society of Hypertension. **BMJ, 322**, 531-536.

Peters, G.L., Binder, S.K., & Campbell, N.R. (1999). The effect of crossing legs on blood pressure: a randomized single-blind cross-over study. **Blood pressure monitoring, 4**(2), 97-101.

Pickering, T.G. (2002). Principles and techniques of blood pressure measurement. **Cardiology clinics, 20**(2), 207-223.

Poggi, L., Vaïsse, B., Silhol, F. & Bouchlaghem, K. (2000). **Serveur pédagogique : La pression artérielle et sa mesure clinique**. Faculté de Médecine de Marseille – Université de la Méditerranée

http://medidacte.timone.univ-mrs.fr/learnet/webcours/hta/pressionart/intro.htm

Prinea, R.J., & Jacobs, D. (1983). Quality of Korotkofff sounds: Bell versus diaphragm, cubital fossa versus brachial artery. **Preventive medicine, 12**(5), 715-719.

Reeves, R.A. (1995). Does this patient have hypertension? How to measure blood pressure. **JAMA, 273**, 1211-1218.

Société québécoise d'hypertension artérielle (2002) **Guide thérapeutique. Hypertension artérielle 2002** (2e édition).

Stergiou, G., Vousa, A.V., Achimastos, A.D., & Mountokalakis, T.D. (1997). Home self-monitoring of blood pressure: is fully automated oscillometric technique as good as conventional stethoscopic technique? **American Journal of Hypertension, 10**(4), 428-433.

Tavarese, M. (2003). Énoncé de la Représentante Welch Allyn.

Tholl, U., Forstner, K., & Anlauf, M. (2004). Measuring blood pressure: pitfalls and recommendations. **Nephrol Dial Transplant, 19**(4), 766-770.

Vancheri, F., Alletto, M., & Sidoti, P. (2003). Does this patient have hypertension? Different methodologies in the measurement of arterial pressure. **Recenti progreesi in medicina, 94**(3), 106-109.

Woodrow, P. (2004). Assessing blood pressure in older people. **Nurisng Older people, 16**(1), 29-34.

Competing interests

None

Acknowledgement

I thank Adam Wright and Alan Wright for the translation of the French original article and D.r Jean-Guy Daniels for his helpful comments during preparation of the manuscript.

This article has been peer reviewed

Le magazine des infirmières et infirmiers d'urgence du Québec: info urgence 2004; XVIII:3; 12-17.

Correspondence to the author

Céline Plante, UQAR , Département de biologie – chimie – sciences de la santé, Module des sciences infirmières, 55 rue du Mont-Marie, bureau 227, Lévis, Québec, Canada, G6V 8R9 Phone: (418) 833-8800 ext. 265; e-mail: celine_plante@uqar.qc.ca