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Noninvasive Blood Pressure Monitoring

Infinity Patient Monitors

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Abstract:
The methods of measuring noninvasive blood pressure (NBP) differ significantly from that of measuring invasive blood pressure. This paper provides an overview of noninvasive blood pressure measuring methods and discusses the technology behind Dräger Medical's Infinity NBP system.

TECHNICAL ABSTRACT

Introduction

Blood pressure is considered to be one of the most important vital signs during patient assessment because it can provide clinicians with a fast indication of cardiovascular performance. Technological advancements have ensured that automated devices intended for measuring noninvasive blood pressure (NBP), provide fast, accurate results even in the more challenging patients. Dräger Medical's Infinity® NBP system uses the oscillometric method with step-deflation to provide accurate, reliable, measurements, equivalent to those obtained by intra-arterial methods, according to the ANSI/AAMI SP10 standard.

Noninvasive blood pressure (NBP) Measuring methods

The two most common methods of measuring NBP are auscultatory and oscillometric, both of which are described below.

Auscultatory method

The auscultatory method is the original technique that has been used by many doctors and remains the most common method of measuring NBP today. It is based on the principle of manually inflating a cuff around the arm (typically), occluding the brachial artery, slowly releasing the occlusion, and listening for Korotkoff sounds. Korotkoff sounds are caused by the hammering of the blood against the arterial wall when the compression of the artery is released. The onset of Korotkoff sounds denotes the systolic pressure while the complete disappearance of Korotkoff sound signifies the diastolic pressure.[1]

Oscillometric method

The oscillometric method of measuring is used in most bedside patient monitors and although there are some variances between manufacturers, the principle method is the same. With this technique, a cuff is also applied to the patient's arm or leg and is inflated to a point above their systolic pressure, subsequently occluding blood flow through the artery. In Dräger Medical's Infinity patient monitors, the cuff is then deflated at various pressure levels, allowing blood to flow back through the artery in steps (Figure 1). As the pressure in the cuff is reduced, the blood pressure pulses within the artery distend the soft tissues of the limb. These fluctuations in arm circumference cause pneumatic pressure oscillations in the cuff, which can be sensed by transducers within the monitor. During the cuff deflation, the onset and increase of oscillations denotes the supra-systole region. The maximum oscillation sensed indicates the mean blood pressure pulse, while the diastole region is marked by a decrease and disappearance of oscillations.

The NBP monitor deflates the cuff one step each time it detects two oscillations of relatively equal amplitude ('peak detection'). The time between deflation steps depends on the frequency of these matched pulses. However, if the NBP monitor is unable to find a pulse within several seconds, it will deflate to the next step. The process of finding two matched oscillations at each step provides artifact rejection due to patient movement and greatly enhances accuracy.

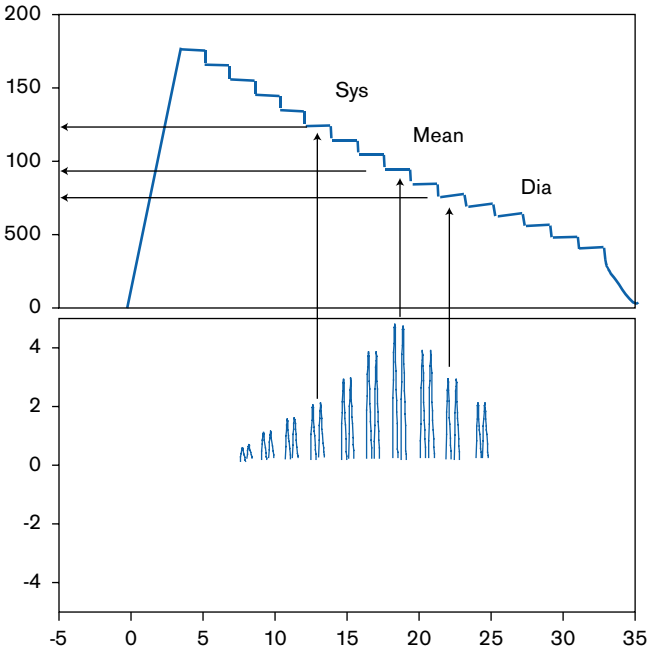

Figure 1
Stepped deflation cuff pressure (upper trace).
By zooming in on the cuff pressure, the small oscillations generated by blood flow through the arteries, are visible (lower trace). The peak oscillation corresponds to the Mean Arterial Pressure.

Accuracy

Invasive blood pressure (IBP) monitoring is considered to be the gold standard of blood pressure monitoring by many clinicians because it directly measures the pressure wave itself on a beat-by-beat basis. This differs from both the oscillometric and auscultatory methods, which measure blood flow indirectly and approximate the blood pressure over the time it actually takes to do the measurement. In clinical practice it is very common to compare one measurement against the other, however all methods differ in their measurement technique and have their inherent advantages and disadvantages.

Auscultatory versus oscillometric methods

The accuracy of the auscultatory method relies on the ability of the human ear to detect and distinguish sounds. Experienced clinicians can determine the quality of each measurement. However, inexperienced clinicians may be inconsistent in their assessment of the Korotkoff sounds and be unable to distinguish them from outside noise or other interference. It is also important to note that the auscultatory method measures the systolic and diastolic pressure, and the mean is normally calculated based on the following formula, MAP = (SYS + 2DIA)/3, which can be very inaccurate in certain situations.[2,3,4] Oscillometric devices measure the mean pressure and derive the systolic and diastolic pressures. Other factors that can influence the accuracy in both methods are incorrect cuff size, incorrect placement, and excessive patient movement.

Oscillometric versus invasive blood pressure measurement

In the ICU, it is common practice to compare the radial IBP and NBP values. In some cases, differences may be observed. If both sets of equipment are set up accurately, comparison of the NBP to the radial artery IBP will reveal a higher peripheral IBP systolic pressure. As the blood pressure waveform travels through the cardiovascular system away from the aorta, reflectance of the pulse waveforms sum to falsely heighten the pressure amplitude. Reflectance is the phenomenon where the arterial pressure wave gets added to itself at the peripheries and causes an artificial increase in the measured systolic blood pressure. Also, stiffness (or compliance) of the cardiovascular system can alter the amplitude and shape of the waveform, causing different IBP readings from the aorta to the peripheral arteries. Because of the different amplitude in different regions, the best comparison is with the mean arterial pressure (MAP).

Accuracy of Infinity monitors

The NBP system in Infinity modular monitors (Delta/Delta XL/Kappa, formerly SC 7000/8000/9000XL) was tested according to the Association for the Advancement of Medical Instrumentation (AAMI) standard for automated sphygmomanometers (SP10), and included a statistical comparison between NBP measurements and direct pressure measurements.

Following the prescribed study methods, paired measurements were obtained for all patient categories. For systolic, mean and diastolic pressures respectively, the difference between the intra-arterial measurement and the non-invasive measurement were determined and the mean bias and the standard deviation of the bias were calculated. For purposes of data presentation and analysis, adult/pediatric and neonatal/infant subjects were treated separately.

Data analysis

Results from the pooled data are summarized in Tables 1 and 2. Bias for each measurement was determined by subtracting the NBP test value (systolic, diastolic and mean) from the intra-arterial range during the same interval, as determined from a continuous recording of the invasive blood pressure waveform. NBP values falling within the intra-arterial range were assigned a difference of zero. This methodology is widely accepted, as NBP is not intended as an absolute, beat-to-beat value, rather a measure of the patient's condition during the monitored interval.

	Systolic	Diastolic	Mean
Range	70-200	36-102	62-131
Paired Measurements (n)	193	193	193
Mean Difference (Bias)	1.18	1.36	0.24
Standard Deviation (SD)	7.08	5.23	5.23

Table 1
Measure of the Differences - Adult/Pediatric

	Systolic	Diastolic	Mean
Range	37-113	22-74	32-94
Paired Measurements (n)	173	173	173
Mean Difference (Bias)	1.24	-2.23	-1.58
Standard Deviation (SD)	6.73	6.34	6.58

Table 2
Measure of the Differences - Neonate/Infant

Conclusion

The analysis of the data collected shows that the Infinity NBP system using stepped deflation, meets the accuracy requirements of the AAMI SP10 standard, with a mean bias <5 mmHg, and a standard deviation <8 mmHg in all cases. This demonstrates that the Infinity NBP system provides accurate, consistent measurements in the designated patient populations.

References:

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TECHNICAL ABSTRACT

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