Arterial blood pressure monitoring using three different technologies during neuro radiological procedure: a prospective, monocentric, observational study

Xavier Chapalain
University and Regional Hospital Centre Brest
Thomas Morvan
University and Regional Hospital Centre Brest
Jean-Christophe Gentric
University and Regional Hospital Centre Brest
Aurélie Subileau
University and Regional Hospital Centre Brest
Christophe Jacob
University and Regional Hospital Centre Brest
Anna Cadic
University and Regional Hospital Centre Brest
Anaïs Caillard
University and Regional Hospital Centre Brest
Olivier Huet (olivier.huet@univ-brest.fr)
University and Regional Hospital Centre Brest

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Abstract

Background

In the perioperative setting, the most accurate way to continuously measure Arterial Blood Pressure (ABP) is using an arterial catheter. Surrogate methods such as finger cuff have been developped to allow non invasive measurements and are increasingly used, but needs further evaluation. The aim of this study is to evaluate accuracy and clinical concordance between three devices for the measurement of ABP during neuroradiological procedure.

Methods

This is a prospective, monocentric, observational study. All consecutive patients undergoing a neuro radiological procedure were eligible. Patients who needed arterial catheter for blood pressure measurement were included. During neuroradiological procedure, ABP (systolic, mean and diatolic blood pressure) was measured with three different technologies: radial artery catheter, Arm Cuff and Nexfin. Bland-Altman and error grid analysis were performed to evaluat accuracy and clinical concordance between devices.

Results

From March 2022 to November 2022, we included 50 patients, mostly ASA 3 (60%) and required a cerebral embolization (94%) under general anaesthesia (96%). Compare to artery catheter, a significant relationship was found for SAP ($r^2 = 0.78$) and MAP ($r^2 = 0.80$) with the Nexfin ($p < 0.001$). Bias and limits of agreement (LOA) were respectively 9.6 mmHg (-15.6 to 34.8 mmHg) and − 0.8 mmHg (-17.2 to 15.6 mmHg), for SAP and MAP. We found a significant relationship for SAP ($r^2 = 0.82$) and MAP ($r^2 = 0.74$) with Arm Cuff ($p < 0.001$). Bias and LOA were respectively 5.8 mmHg (-30.4 to 22.9 mmHg) and − 1.4 mmHg (-17.3 to 14.4 mmHg), for SAP and MAP. Error grid analysis showed that 99% of non-invasive ABP measures obtained with the Nexfin and Arm Cuff were located in the risk zone A or B.

Conclusions

Despite an inaccuracy which are larger than acceptable, ABP measurement with non-invasive devices induced almost no changes in individual patient care during neuro radiological procedure.

Trial registration:

Clinicaltrials.gov, registration number: NCT05283824

Introduction

There are growing evidences about the risk of hypertensive and hypotensive events during the perioperative period, making arterial blood pressure (ABP) probably one of the most important parameter to optimize (Abbott et al. 2018; Halvorsen et al. 2022; Salmasi et al. 2017). During major surgery, a low ABP and its variability have been associated with a higher risk of mortality, myocardial infarction, stroke and acute kidney injury (Gregory et al. 2021; Mascha et al. 2015; Salmasi et al. 2017). A high blood pressure may also be harmful and may increase the risk of perioperative haemorrhage, cerebrovascular events, and myocardial infarction (Abbott et al. 2018; Reich et al. 2002). Recently, two experts consensus statement emphasized the need of a strict blood pressure control to improve perioperative care (McEvoy et al. 2019; Sessler et al. 2019).

Neuro radiological procedures can be considered as a high risk procedure and it has been reported that hypotensive events might be associated with brain damage (Collette et al. 2021; Maïer et al. 2019; Valent et al. 2020). Therefore, a reliable and acurate ABP measurement to maintain cerebral perfusion is recommended (Lidington et al. 2021; Muldoon and Appleby 2020). In a recent French consensus statement, experts emphasized the need of a tight ABP control following thrombectomy (Quintard et al. 2023). Intermittent ABP measurement with an automated arm cuff remains the most used device in the operating room and it has been recommended by the American Society of Anaesthesiologists as a standard of care during anaesthesia (Fellahi et al. 2021; Halvorsen et al. 2022; Vallet et al. 2013). However, the gold standard for continuous ABP measurement remains the placement of an arterial catheter in the radial or the femoral artery. This technic may exposes the patient to local complications such as: bleeding, arterial thrombosis, aneurysm or infection (Scheer et al. 2002). Even if invasive method had some advantages, the catheterization of radial or femoral artery may be difficult and delay the procedure (Saver 2006).

Recently, new continuous non-invasive ABP monitoring devices have been developed. Among them, the Nexfin technology is able to continuously measure ABP based on two principles: the volume-clamp method and the photo plethysmography technology.

In the operating room, some studies have shown reliable measures between the Nexfin and invasive measurement with acceptable agreement for ABP (Lu and Dalia 2021; Mukai et al. 2021; Schumann et al. 2021; Wang et al. 2022). To our best knowledge, there is only one observational monocentric study which investigated the accuracy of this new device during neuro radiological procedure (Bugarini et al. 2021). There are only few studies that investigated ‘clinical concordance’ of non-invasive ABP measurement (Bugarini et al. 2021; Kho et al. 2022; Yahagi et al. 2022).

In the current study, we evaluated the accuracy and clinical concordance of ABP measurements provided by two non-invasive devices (Nexfin and intermittent Arm Cuff), compared to those provided by an arterial catheter during elective or emergency neuro radiological procedure. We hypothesized that ABP measures provided by the Nexfin device are more consistent than those provided by intermittent Arm Cuff compared to ABP catheter measurements.

Materials and methods

Study Design and Population

This is a prospective, observational study conducted in the Department of Anaesthesiology and Surgical intensive care unit at Brest University Hospital Centre. All adult patients admitted in operating room for an elective or emergent neuro radiological procedure and needed the placement of an arterial catheter to measure ABP were eligible. Exclusion criteria were: contraindication of the placement of arterial catheter or digital cuff (Raynaud syndrome or Buerger syndrome), pregnant women and refusal to participate. The study protocol was registered on clinicaltrial.gov (registration number: NCT05283824, date of registration: 17th march 2022).

Ethics

Ethical approval

for this study was provided by the Ethic Committee of Est I (Ethical Committee N°2021-A02255-36) on 16th December 2021. This study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was provided to all eligible patients at inclusion.

Perioperative management

Neuro radiological procedures done under general anaesthesia had the same anesthetic protocol, consisting in a continuous propofol infusion, remifentanil target-controlled infusion and a neuromuscular blocker agent if needed. When performed under local anaesthesia, continuous remifentanil target-controlled infusion was used if deemed necessary. Hemodynamic management was performed using boluses of ephedrine and intraoperative continuous infusion of norepinephrine if deemed necessary by the physician in charge. Mean arterial pressure target was left at the discretion of the physician in charge. At the end of the procedure, all patients were transferred to the recovery room and then admitted in neuro-intensive care unit.

ABP measurement

ABP was monitored as follow:

- First, an automated Arm Cuff was placed on one arm.
- Second, a radial arterial catheter was inserted before the beginning of the procedure on the same arm. The invasive ABP signal was recorded at a frequency of 12 Hz using our standard equipment (Philips Intellivue®). All pressure signals were zeroed at the midaxillary line after the placement of the catheter.
- Third, a continuous non-invasive ABP was measured on the same arm with the Nexfin device with an appropriate digital cuff (Clearsight® from the Edwards Lifesciences® Corporation, Irvine, California, United States). The Heart Reference System sensor was used in order to correct the hydrostatic

pressure difference between the finger and the heart. Afterwards, the finger cuff and the heart reference system were connected to a wrist-processing unit, that was in turn connected to the Hemosphere® clinical platform (Edwards Lifesciences®).

Data collection

We collected demographic characteristics, comorbidities, ASA score, type of neuro radiological procedure and type of anaesthesia. We concomitantly recorded systolic, diastolic and mean arterial blood pressure (SAP, DAP and MAP) every 15 minutes from the beginning to the end of the procedure with both non-invasive device (Nexfin and Arm Cuff) and invasive (radial artery catheter). We also collected a set of measurements immediately before and after the use of norepinephrine.

Objectives

The main objectives of our study were: (i) to compare ABP measures provided by non-invasive (Nexfin and Arm cuff) and invasive device (radial artery catheter) (ii) to evaluate clinical concordance between both devices.

Statistical Analysis

Patient characteristics were summarized using mean, standard deviation (SD) for continuous variables. Number and percentage were used for categorical variables. The values for MAP and SAP were compared for these 3 techniques. To visualize relationship between of the ABP obtained with reference method and the two non-invasive devices, the arterial pressure values were plotted on a scatterplot, and the associated regression lines were displayed in scatter for MAP and SAP separately. The estimated correlation was calculated using Pearson correlation. Correlation values ≤ 0.20 are poor, while values ≥ 0.80 are excellent.

To assess the agreement between each device, we performed a Bland-Altman analysis and calculated the mean differences between the two non-invasive devices and the reference method (bias) and the 95% limits of agreement. We defined *a priori* the rules to evaluate the accuracy and precision of measures according the Association for the Advancement of Medical Instrumentation (AAMI) 2019 guidelines (Stergiou et al. 2019):

1. MAP: accuracy and precision greater than 5 mmHg
2. SAP: accuracy greater than 5 mmHg and precision greater than 8 mmHg

To assess the accuracy of the 3 technologies to measure changes in ABP, we measured the concordance rate which corresponded to the trend of changes before and after introduction of vasopressor (Saugel et al. 2015).

Clinical relevance of the differences between each devices was assessed using an error grid analysis (Saugel et al. 2018). Error grid analysis assigns a specific risk level value, ranking from A to E, for each

pair of measured arterial pressures (Saugel et al. 2018). The risk levels were quantified for SAP and MAP by consensus among 25 international experts (Saugel et al. 2018). The clinical relevance of the difference between invasive and non-invasive monitoring is illustrated by the proportion of measurements in each risk level. Finally, trend in each ABP component (SAP, MAP and SAP) during neuro-radiological procedure will be analysed using a mixed model analysis with patient-level random effect. For any comparison, statistical significance will be defined if p value was above 0.05.

All statistical analysis was performed with R Statistical Software (version 3.6.1). Error grid analysis was performed using the open access software designed by Saugel et al (Saugel et al. 2018).

Results

Patient characteristics

From 18th March 2022 to 30th November 2022, 272 patients were eligible. Among them, 50 patients (15.4%) were included in the study. No statistical difference in baseline characteristics was found between included and excluded patients. Excluded patients were more frequently admitted in operating room for thrombectomy (19.8% vs. 0%, $p < 0.001$) or diagnostic arteriography (58.6% vs. 6%, $p < 0.001$). Included patients were more frequently admitted for the treatment of SAH (12.2% vs. 38%, $p < 0.001$). An additional file illustrate the comparison between included and excluded patients [see Additional file 1]. Most patients were excluded due to the absence of invasive blood pressure monitoring during the procedure. Another subject was also excluded due to the impossibility of obtaining a valuable ABP curve on the Nexfin device. An additional file show the flow diagram of the study [see Additional file 2]. Enrolled patients were mainly women (62%), with a mean age of 58 (± 12) years and were mostly ASA 2 (28%) or ASA 3 (60%). Half of patients had hypertension or other cardiovascular comorbidities. Nearly all patients were admitted in the operating room for a cerebral embolization (94%) under general anaesthesia (96%). Nineteen patients (38%) needed an emergency procedure for SAH. Baseline characteristics are summarized in Table 1.

Table 1
Baseline characteristics

	Overall
	n = 50
Age (years)	58 (12)
Gender (men/women)	19/31
Weight (kg)	71.1 (16.5)
BMI (kg/m^2)	25.2 (5.2)
Core temperature (°C)	36.5 (0.6)
SAPS II	23.8 (8.3)
Comorbidities	
Cardio-vascular	25 (50)
Myocardial infarction	4 (8)
Arrhythmia	1 (2)
Hypertension	25 (50)
Arteritis	1 (2)
COPD	3 (6)
Diabetes	1 (2)
Chronic kidney disease	5 (10)
Medication	
Anti-hypertensive agents	20 (40)
Beta-blockers	2 (4)
ASA score	
1–2	31 (63.2)
3–5	19 (36.8)
Emergency procedure for SAH	19 (38)
Fisher score	
1–2	2 (10.6)
3	5 (26.3)

	Overall
	n = 50
4	12 (63.2)
WFNS score	
1	14 (73.7)
2	1 (5.3)
4	2 (10.5)
5	2 (10.5)
Type of procedure	
Embolization	47 (94)
Other	3 (6)
General anaesthesia	48 (96)
Norepinephrine infusion	17 (34)

Data are given as n (%) or mean ± SD. ASA: American Society of Anaesthesiologists; BMI: Body Mass Index; COPD: Chronic Obstructive Pulmonary Disease; SAH: Sub-Arachnoid Haemorrhage; SAPS: Simplified Acute Physiology Score; SD: Standard Deviation; WFNS: World Federation of Neurologic Surgeons.

Accuracy of ABP measurements

In our dataset, we recorded 380 different paired ABP measurements with the Nexfin and the arterial catheter. Compared to invasive measurements, the Nexfin device showed a good correlation for measures of SAP ($r^2 = 0.78$, $p < 0.001$) and MAP ($r^2 = 0.82$, $p < 0.001$) (Fig. 1A and 1D). Between the two devices (arterial catheter and the Nexfin), Bland-Altman analysis showed a mean bias of 9.6 mmHg (-15.6 to 34.8 mmHg) for SAP and − 0.8 mmHg (-17.2 to 15.6 mmHg) for MAP (Fig. 2A and 2D). Three hundred and seventy one different paired ABP measurements between intermittent arm cuff and arterial catheter were also recorded. Compared to invasive measurements, the Arm Cuff showed a good correlation for SAP ($r^2 = 0.80$, $p < 0.001$) and MAP ($r^2 = 0.74$, $p < 0.001$) (Fig. 1B and 1E). Between the two devices (arterial catheter and Arm Cuff), Bland-Altman analysis showed a mean bias of 5,8 mmHg (-30.4 to 22.9 mmHg) for SAP and − 1,4 mmHg (-17.3 to 14.4 mmHg) for MAP (Fig. 2B and 2E). Three hundred and seventy two different pairs of ABP measurement between intermittent Arm Cuff and the Nexfin device were recorded. Compared to Arm Cuff, the Nexfin showed a good correlation for SAP ($r^2 = 0.71$, $p < 0.001$) and MAP ($r^2 = 0.63$, $p < 0.001$) (Fig. 1C and 1F). Between the two devices (Arm Cuff and the Nexfin), Bland-Altman analysis showed a mean bias of -3.8 mmHg (-30.4 to 22.9 mmHg) for SAP and − 0.6 (-22 to 20.8 mmHg)

for MAP (Fig. 2C and 2F). For DAP measurements, the three devices showed a moderate to good correlation. An additional file show the relationship between absolute values of DAP on invasive and non-invasive devices [see Additional file 3]. DAP measurements obtained with arterial catheter and the Nexfin showed the best correlation ($r^2 = 0.72$, $p < 0.001$). Compared to arterial catheter, Bland-Altman analysis showed a mean bias of -3.7 (-19.9 to 12.5 mmHg) and − 7 (-24.4 to 10.4 mmHg) respectively, for the Nexfin and the Arm Cuff. An additional file show the Bland-Altman analysis of DAP obtained with invasive and non-invasive devices [see Additional file 4]. Compare to the Arm Cuff, a mean bias of -3.3 (-24 to 17.4 mmHg) was recorded for the Nexfin device's measurements.

Analysis of ABP changes during norepinephrine infusion

Compared to the ABP changes with the radial artery catheter (before and after the beginning of norepinephrine), the four-quadrant plot analysis showed a concordance rate of 92% and 70% respectively for the ABP changes measured with the Nexfin and the Arm Cuff (Fig. 3A and 3B). With the same analysis, ABP changes measured with the Nexfin and the arm Cuff were concordant in 76% (Fig. 3C).

Clinical concordance

Compared to the arterial catheter, the error grid analysis revealed that 91.3% of SAP were in zone A, 8.1% were in zone B and, 0.5% in zone C for the Nexfin (Fig. 4A). Considering the MAP, 86.1% of the measurements pairs were in zone A and 13.9% in zone B (Fig. 4B). In the same analysis, 95.4% of SAP were in zone A with intermittent Arm Cuff, 3.7% were in zone B and 0.8% in zone C (Fig. 4C). MAP measurement with intermittent arm cuff were in zone A for 77.1%, in zone B 22.5% and 0.2% in zone C (Fig. 4D). The comparison between Nexfin and the arm cuff pressure measurements showed 89% of the reading in zone A, 10.4% in zone B and 0.05% in zone C for SAP, whereas for MAP there were 82.3% in zone A, 16.6% in zone B, 1.1% in zone C (Fig. 4E and 4F).

Evolution of ABP in each device

In comparison to arm cuff, SAP measures with invasive method were significantly higher ($p < 0.001$) and SAP measures with Nexfin were significantly lower ($p < 0.001$). In comparison to arm cuff, MAP measures with invasive method were significantly lower ($p < 0.01$). In comparison to arm cuff, DAP measures with invasive method were significantly lower ($p < 0.001$) and DAP measures with Nexfin were significantly lower ($p < 0.001$). An additional file illustrate the trend in each ABP parameter [see Additional file 5].

Discussion

The main findings of the current observational study are: (i) Neither Nexfin, nor intermittent Arm Cuff reached the AAMI criteria (Stergiou et al. 2019) (ii) During an elective or emergent neuro radiological procedure, our error grid analysis showed that 99% of non-invasive ABP measures obtained with Nexfin and intermittent Arm Cuff were located risk zone A ('no risk') and risk zone B ('low' risk). Therefore,

therapeutic consequences during a neuro radiological procedure might be anecdotal if non-invasive measurements replace the invasive one.

Previous studies have already investigated the accuracy of finger cuff technologies to measure ABP in the peri-operative setting (Kim et al. 2014; Saugel et al. 2020). Only one study performed in the context of carotid endarterectomy, demonstrated interchangeability with invasive measures (Heusdens et al. 2016). These findings and our results are in line with two meta-analysis (Kim et al. 2014; Saugel et al. 2020). In the most recent one, Saugel et al. found a pooled estimate for MAP bias of 4.19 with a limit of agreement from – 13.99 to 22.47 mmHg (Saugel et al. 2020). In the same study, Saugel et al. also demonstrated that invasive and finger cuff technologies are not interchangeable for SAP and DAP measurements (Saugel et al. 2020). Only 7% of the included studies found a complete accuracy between invasive and finger cuff technologies in regards to AAMI criteria (Saugel et al. 2020; Stergiou et al. 2019). In neurocritical care setting, one small observational study conducted in a stroke emergency department found a good correlation between non invasive continuous blood pressure measured with the Nexfin device and standard measurement with arm cuff (Sen et al. 2014). During neuro radiological procedure, the studies are scarce (Bugarini et al. 2021). In this specific setting, only one smallest study was published in this setting concluding that Clearsight® is not interchangeable with invasive device in regards to AAMI criteria (Bugarini et al. 2021). Moreover, the number of exclusion criteria (such as advanced peripheral vascular disease, atrial fibrillation or peripheral oedema) limited the generalizability of their findings (Bugarini et al. 2021). To the best of our knowledge, our study is the first one reporting concomitantly accuracy and limit of agreement for finger cuff, arm cuff and invasive method in this setting.

Although Bland-Altman statistic remains a key analysis to evaluate accuracy, it doesn’t assess the clinical relevance of the maesurements compare to the gold standard (Saugel et al. 2018). The error grid analysis developed by Saugel et al. may help researchers to evaluate the clinical consequences in adopting an innovative device even if bias and limit of agreement are higher than recommended (Saugel et al. 2020). Only few studies have already evaluated clinical consequences in adopting finger cuff technologies rather than invasive method to measure ABP in perioperative setting (Bugarini et al. 2021; Schumann et al. 2021). During endarterectomy, ABP measurements with Nexfin instead of radial artery was not associated with an increase of proportion of patients outside a predefined ABP target before cross-clamping period (Heusdens et al. 2016). In obese patients, 77.1% and 89.5% of paired measures, respectively for MAP and SAP, were not associated to therapeutic consequences (Schumann et al. 2021). Moreover, They reported comparable results to our study as 99% of paired measurs were located in the risk zone A (‘no’ risk) and risk zone B (‘low’ risk) in error grid analysis (Schumann et al. 2021). In the only published study in a neuro radiological setting, Bugarini et al. underlined that more than 85% of ABP paired measures were categorized in ‘no’ risk or ‘low’ risk zone, which is a percentage lower than our findings (Bugarini et al. 2021).

Study implications

Our findings are in line with the results of previous meta-analysis and found that the ABP measure with an invasive method is not strictly interchangeable with non-invasive devices (Kim et al. 2014; Saugel et al. 2020). Accordingly to our error grid analysis, we also found that the swap of invasive measurement to a non-invasive one might not be associated with any detrimental side effects or clinical draw back. As arterial catheterisation can be associated with potential harmful effects and may be a time consuming procedure, the use of non-invasive device for ABP measurements may be a safe and reliable alternative. As this technology has a higher concordance rate to track therapeutic changes in our study, Nexfin could probably be a better choice compare to the Arm Cuff. Moreover, the nexfin, as other finger-cuff technologies, provides a continuous ABP measurement which is probably more accurate for high-risk neuro radiological procedure.

Strength and limitations

The main strength of our study is the design as it is a prospective study. All consecutive patients were screened for eligibility and screening information were described in the flowchart of the study. Moreover, we also included patients who needed emergency procedures which hasn't been done in other similar study (Schumann et al. 2021). Data collection for ABP measures were standardized before the beginning of the study. This process was well-described in the study protocol and limits an evaluation bias. Lastly, we compared in the same population three different ways to measure ABP during a standardized interventional procedure.

Our study has also some limitations. It is a monocentric study. Furthermore, 43 eligible patients were not included in the final cohort, as research staff was unavailable at the day of the procedure. Thus, our study may suffers from selection bias and our results might not be applicable to other settings. Second, the number of paired ABP measures smaller compared to other study (Bugarini et al. 2021). Our study is not a randomised controlled trial and anaesthesiologists were not blinded to either devices.

Conclusion

Considering AAMI criteria, non-invasive ABP monitoring devices are not interchangeable with invasive method during neuro radiological procedure. Nevertheless, the measurement of blood pressure with these two devices seems be safe and are probably a reliable alternative to invasive blood pressure monitoring during elective and emergent neuro radiological procedure.

Abbreviations

AAMI: Association for the Advancement of Medical Instrumentation; ABP: Arterial Blood Pressure; DAP: Diastolic Arterial Pressure; LOA: Limits of agreement; MAP: Mean Arterial Pressure; SAH: Sub-Arachnoid Hemorraghe; SAP: Systolic Arterial Pressure; SD: Standard Deviation.

Declarations

Ethics approval and consent to participate: The study protocol was approved by the Ethic Committee of Est I (N°2021-A02255-36) on 16th December 2021. Informed consent was given by the patients or their caregivers.

Consent for publication: A written inform consent for publication was obtained.

Availability of data and materials: The dataset supporting the conclusions of this article is fully available. To have an access on it, please contact the corresponding author (OH)

Competing interests: OH received honorary for consulting and symposium presentation from Edwards LifeScience. Other authors reported no conflict of interest related to this study.

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Figures

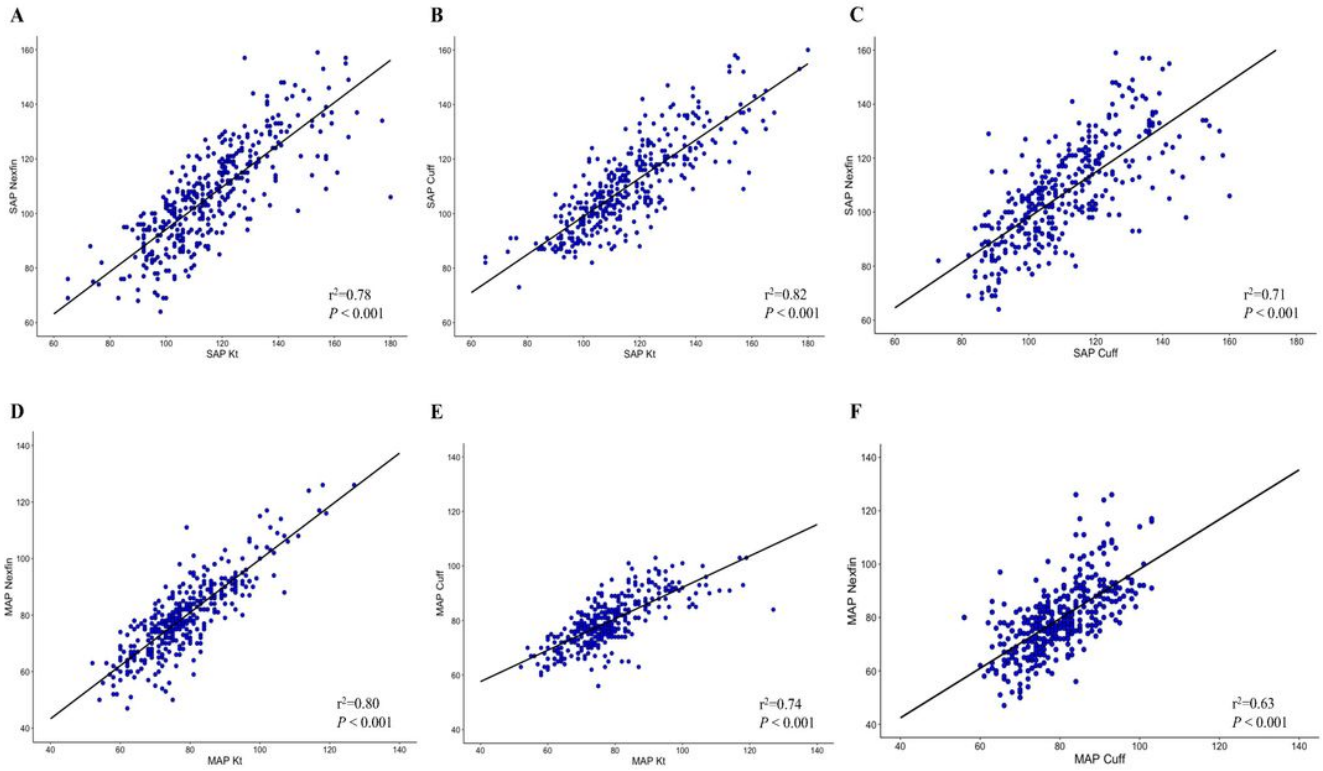

Figure 1

The relationship between absolute values of ABP measurement (SAP and MAP) on invasive (radial artery, Kt) and non-invasive (Nexfin and Arm Cuff) devices. A: SAP measures with Nexfin and invasive method (380 pairs). B: SAP measures with intermittent Arm Cuff (Cuff) and invasive method (371 pairs). C: SAP measures with intermittent Arm Cuff (Cuff) and invasive method (374 pairs). D: MAP measures with Nexfin and invasive method (379 pairs). E: MAP measures with intermittent Arm Cuff (Cuff) and invasive method (372 pairs). F: MAP measures with intermittent Arm Cuff (Cuff) and invasive method (374 pairs). ABP: Arterial Blood Pressure; MAP: Mean Arterial Pressure; SAP: Systolic Arterial Pressure.

Figure 2

Bland-Altman analysis between ABP measurement (SAP and MAP) on invasive (radial artery, Kt) and non-invasive (Nexfin and Arm Cuff) devices. Each point corresponds to a pairs of measures. Red dashed lines represents mean bias. Black lines shows the limit of agreement. A: Accuracy and precision for SAP measures between Nexfin device and invasive method. B: Accuracy and precision for SAP measures between intermittent Arm Cuff and invasive method. C: Accuracy and precision for SAP measures between Nexfin device and intermittent Arm Cuff. D: Accuracy and precision for MAP measures between

Nexfin device and invasive method. E: Accuracy and precision for MAP measures between intermittent Arm Cuff and invasive method. F: Accuracy and precision for MAP measures between Nexfin device and intermittent Arm Cuff. ABP: Arterial Blood Pressure; MAP: Mean Arterial Pressure; SAP: Systolic Arterial Pressure.

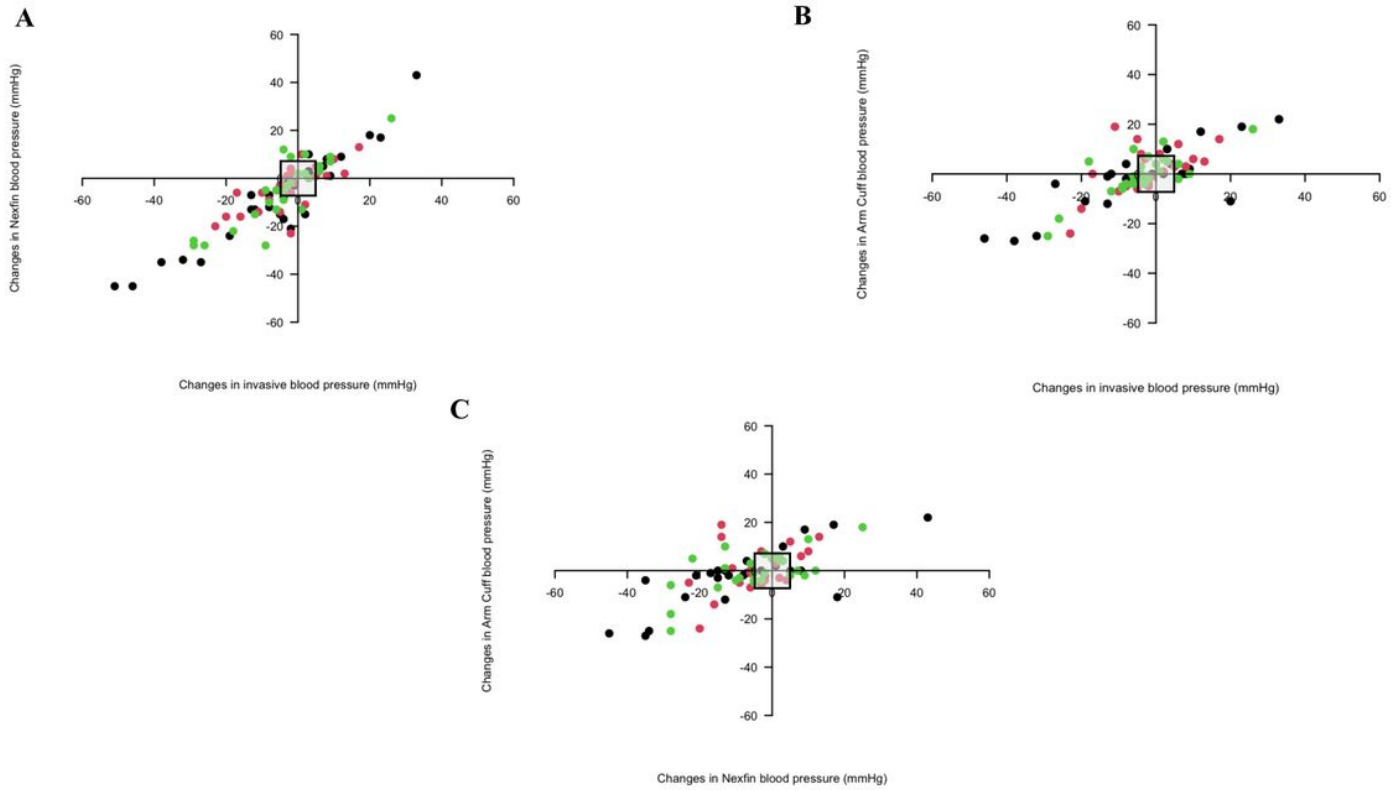

Figure 3

Four-quadrant plot with an exclusion zone of 5 mmHg (grey square) representing the trending in changes between invasive blood pressure and Nexfin blood pressure (A), between invasive blood pressure and Arm Cuff (B) and Nexfin blood pressure and Arm cuff (C) for SAP (black circle), DAP (red circle) and MAP (green circle). All these changes were recorded before and after the introduction of vasopressors during the procedure (30 pairs of measures were recorded for SAP, MAP and DAP). DAP: Diastolic Arterial Pressure; MAP: Mean Arterial Pressure; SAP: Systolic Arterial Pressure.

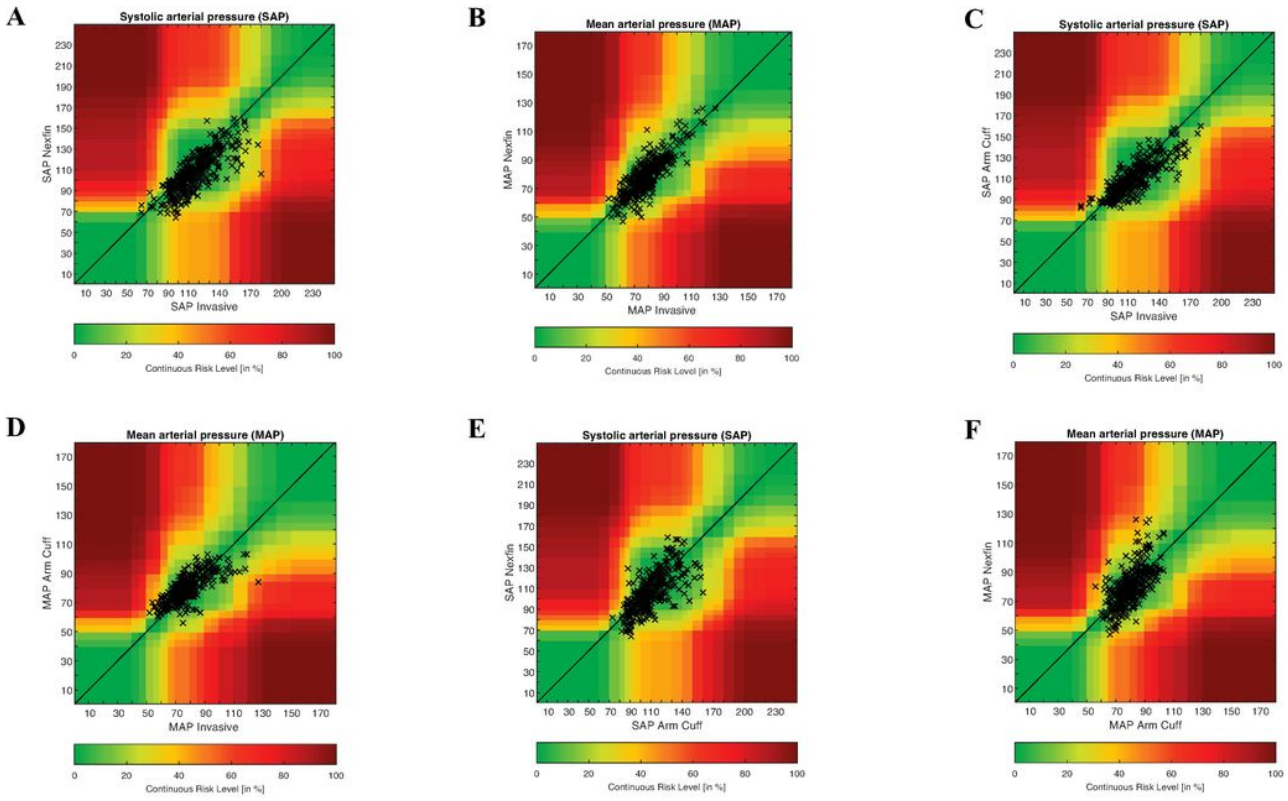

Figure 4

Error grid analysis heatmaps for SAP and MAP measurement with invasive (radial artery) and non-invasive (Nexfin and Arm Cuff) devices. A and B: Comparison between Nexfin and arterial catheter (Invasive). C and D: Comparison between intermittent Arm Cuff and arterial catheter (Invasive). E and F: Comparison between Nexfin and intermittent Arm Cuff. MAP: Mean Arterial Pressure; SAP: Systolic Arterial Pressure.

Supplementary Files

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- SupplementaryMaterials.docx