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Performance of a tonometer for arterial pressure measurement during anesthesia in the elderly

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Abstract
We investigated performance of an arterial tonometer during anesthesia in the elderly. Thirty patients (17 men and 13 women), ranging from 70 to 86 years old, were included, and agreement between tonometric arterial pressure (TAP) and intraarterial pressure (IAP) was calculated. A total of 6487 paired points was sampled, and values for precision (mean absolute difference ± SD) were 6.8 ± 5.2 for systolic, 6.9 ± 4.6 for mean, and 9.2 ± 5.4 mmHg for diastolic blood pressures. Values for bias and limits of agreement [mean difference (TAP − IAP) ± SD, mean difference (TAP − IAP) ± 2 SD, respectively] for systolic, mean, and diastolic pressure were 1.2 ± 8.4 and 1.2 ± 16.8, 5.7 ± 5.9 and 5.7 ± 11.8, and 8.6 ± 6.2 and 8.6 ± 12.4 mmHg, respectively. Compared with previous data, aging is likely to affect the performance of an arterial tonometer.

Key words Tonometry · Arterial pressure · Aging · Atherosclerosis

Arterial tonometry has been developed to monitor real-time radial artery pressure and its waveform [1]. Although tonometric arterial pressure has been measured in various clinical situations [1–3], how arterial tonometry is affected by the degeneration associated with aging has not been clarified. In addition, in older patients, preoperative complications such as hypertension and diabetes mellitus may exist, which are regarded as promoters of atherosclerosis [4]. Furthermore, hypertension induces arterial wall stiffening [5], which may also make it more difficult for a tonometer to appropriately compress the radial artery. Accordingly, we tested the performance of arterial tonometry in elderly patients under general anesthesia.

Thirty-two patients aged 70 years or older and scheduled for surgery, in whom arterial cannulation to monitor invasive arterial pressure was feasible, were involved in this study after institutional approval and informed consent. Two patients were excluded from the later analyses because their blood pressures showed a difference greater than 10 mmHg between the bilateral arms. The mean age of the 30 patients (17 men and 13 women) was 75, ranging from 70 to 86 years old. There were 12 hypertensive and 5 diabetic patients at preoperative evaluation. Either abdominal or urological surgery was performed under general anesthesia combined with spinal or epidural anesthesia. Tonometric arterial pressure (TAP) was monitored at the site of the epiphysis of the radius and just above the radial artery using an applanation tonometer (Jentow; Colin Medical Technology, Komaki, Japan). This device was calibrated every 10 min (every 5 min during the first several calibrations) by the oscillometric brachial artery pressure using a cuff attached to the ipsilateral upper arm. After confirming the anastomosis between the radial and the ulnar arteries by Allen's test, the contralateral radial artery was cannulated for direct monitoring of intraarterial pressure (IAP) using a disposable monitoring kit (Transpac; Abbott Laboratories, North Chicago, IL, USA). Data of both blood pressure measurements were sampled in a computer every 30 s and their waveforms were recorded on videotapes. Regression analysis was performed, and values for precision, bias, and limits of agreement in systolic, mean, and diastolic pressure were calculated using the following formulae [6]:

Precision: mean absolute difference of the two blood pressure measurements

$$= \left(\sum_{i=1}^{n} \left| \text{error}_i \right| \right) \Big/ n \qquad \text{error}_i = \text{TAP}_i - \text{IAP}_i$$

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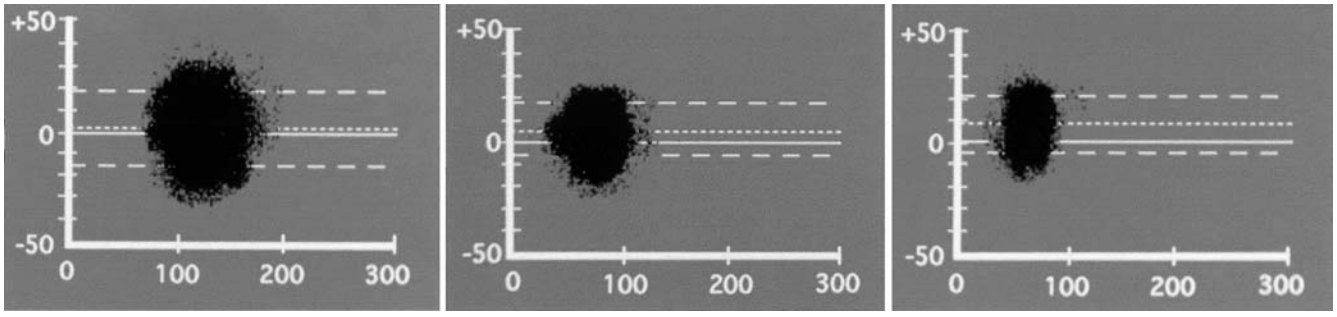

Fig. 1. Scatter plots show limits of agreement between tonometric arterial pressure (TAP) and intraarterial pressure (IAP) in systolic (*left*), mean (*center*), and diastolic (*right*) blood pressure. *x*-axis, (TAP + IAP)/2 (mmHg); *y*-axis, TAP − IAP (mmHg)

Table 1. Bias, precission, and limits of agreement in systolic, mean, and diastolic blood pressure

	Systolic	Mean	Diastolic
Bias (mmHg)	1.2	5.7	8.6
Precision (mmHg)	6.8	6.9	9.2
Limits of agreement (mmHg)	1.2 ± 16.8	5.7 ± 11.8	8.6 ± 12.4

Limits of agreement are expressed as bias ± 2 SD

Bias: mean difference of the two blood pressure measurements

$$= \left(\sum_{i=1}^{n} \text{error}_i \right) \Big/ n \qquad \text{error}_i = \text{TAP}_i - \text{IAP}_i$$

Limits of agreement: range expressed by mean difference ± 2 SD

= bias ± 2 SD

A total of 6487 paired points was sampled from 30 patients for systolic, mean, and diastolic blood pressure. Values for precision (mean absolute difference ± SD) were 6.8 ± 5.2 for systolic, 6.9 ± 4.6 for mean, and 9.2 ± 5.4 mmHg for diastolic blood pressure (Table 1). Values for bias and limits of agreement [mean difference (TAP − IAP) ± SD, mean difference (TAP − IAP) ± 2 SD, respectively) were 1.2 ± 8.4 and 1.2 ± 16.8 for systolic, 5.7 ± 5.9 and 5.7 ± 11.8 for mean, and 8.6 ± 6.2 and 8.6 ± 12.4 mmHg for diastolic blood pressure (Fig. 1).

In a previous study for 28 patients aged 31–60 years, values for the mean difference (TBP − IBP) ± SD were 0.8 ± 5.8 for systolic, 0.2 ± 4.8 for mean, and −0.1 ± 5.4 for diastolic blood pressure [1]. Compared with these data, it is likely that agreement between TAP and IAP is better in adult patients who are not elderly than in those who are elderly. The elastic fibers of the skin decrease with aging [7], which may cause difficulty in placing the sensor house and in adequately flattening the underlying radial artery. In addition, promoters of atherosclerosis such as hypertension and diabetes mellitus may exist in older patients, as was seen in this study. These changes make it more difficult for a tonometer to correctly measure arterial pressure.

Thus, aging is likely to affect the performance of an arterial tonometer.

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