Are blood pressure monitors affected by high altitude?

Willem J Verberk,1,2 Stephan Mieke3

The importance of accurate blood pressure measurement cannot be overemphasised, and there is an overall understanding that validated blood pressure monitors are needed for reliable pressure measurement. However, some researchers have raised the question whether high altitude, mainly due to the lower atmospheric pressure, can affect the accuracy of automatic blood pressure monitors.1–3

In the current issue of the journal, Mingji et al present a systematic review about the accuracy of blood pressure measuring devices in the Tibetan areas of China.4 The authors conclude that oscillometric blood pressure monitors, which are validated at sea level, agree well with the mercury sphygmomanometer for diastolic blood pressure measured at high altitudes, but the degree of such accuracy for systolic blood pressure is not consistent.

However, the two studies that were included in the review and led to this conclusion show some significant differences in both material and methods between its performance at sea level and high altitude. Therefore, it should be questioned whether the obtained blood pressure differences can be ascribed to high altitude.

In most blood pressure measurement studies performed at high altitude, researchers question the accuracy of oscillometric devices but assume that the mercury sphygmomanometer is not affected by high altitude. However, for a good understanding of the technical aspects of blood pressure measurement at high altitude, two questions should be answered first:
1. Is it correct to assume that the mercury blood pressure monitor is unaffected by high altitude?
2. Is there a reason to believe that oscillometric blood pressure monitors are affected (or at least are more affected than mercury sphygmomanometers) by high altitude?

To start with the first question: mercury blood pressure monitors measure relative or so-called gauge pressure, which means that measurements are performed with respect to the surrounding atmosphere (figure 1). Since the tubing of the column of mercury is open to atmospheric pressure, the manometer will measure only the relative pressure change. A closed riser tube evacuated to vacuum would show the atmospheric pressure. Other aspects that are suggested to have a possible influence on the measurement such as gravity and density change5 can have no influence as the effect of the first can be neglected (to give an indication: −1.2% less gravity at 40 km above sea level) and density does not depend on altitude.

Based on these considerations, it is, therefore, reasonable to assume that the mercury sphygmomanometer is not affected by altitude.

This brings us to the second question: Is there a reason to assume that oscillometric blood pressure monitors are affected by high altitude? For this, the answer is almost identical as for the mercury device. Similar to the mercury device, the oscillometric blood pressure monitor is an open system that measures relative pressure. Figure 2 shows a piezo-resistant transducer that is often used for measuring pressure in automated sphygmomanometers. The cuff pressure is effective in the pressure chamber of the transducer. The piezo material changes its electric resistance due to the pressure applied. Since there is a hole on the backside of the housing, the measurement performed is a relative one, that is, independent from the atmospheric pressure and altitude.

Theoretically, the amplitude of the oscillometric vibrations could be increased by high altitude. However, the algorithm to determine the systolic and diastolic blood pressure values is based on the relative height of the mean arterial pressure (MAP) amplitude. Oscillometric blood pressure monitors measure the MAP represented as the maximum amplitude of the oscillations located in the middle of the oscillometric wave. The systolic blood pressure is encountered when the cuff pressure oscillations are about half the size (50%) of the maximal amplitude at the left of the MAP. The diastolic blood pressure is obtained when the oscillations are about 70% of the height of the

---

1 Cardiovascular Research Institute Maastricht (CARIM), Maastricht University, Maastricht, The Netherlands; 2 Department of Research and Development, Microlife Corporation, Taipei, Taiwan; 3 Physikalisch-Technische Bundesanstalt, Berlin, Germany

Correspondence to Dr Willem Verberk, Cardiovascular Research Institute Maastricht (CARIM), Maastricht University, PO Box 616 6200 MD, The Netherlands; willem.verberk@maastrichtuniversity.nl

---

Figure 1 Schematic drawing of a mercury (Hg) manometer. When the pressure is raised in the cuff by pumping, the Hg level in the reservoir will drop and force the Hg level in the Hg column to rise. On top of the tubing is a stopping device, allowing the air to pass but not allowing Hg to pass to avoid Hg spillage.
In summary, based on the technical aspects of oscillometric and mercury blood pressure monitors, there is no reason to assume that altitude and/or lower barometric pressure will have any effect on their accuracy. This assertion may be best tested by performing measurements with a simulator at sea level and comparing these with measurements at lower atmospheric pressures. This could be done in a pressurised chamber in a laboratory or at different altitudes.

**Contributors** Both authors contributed equally to the article.

**Competing interests** WJV is an employee of Microlife, manufacturer of blood pressure monitors.

**Provenance and peer review** Commissioned; internally peer reviewed.

To cite Verberk WJ, Mieke S. Heart Asia 2016;8:52–53. doi:10.1136/heartasia-2016-010814

**REFERENCES**


---

**Figure 2** Piezo-resistant pressure transducers divided by cutting.