

6. Measuring and evaluating blood pressure

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Q6-1: How is blood pressure measured in people with upper limb impairments?

Blood pressure (BP) is measured using an electronic BP monitor, with a cuff wrapped around the ankle so that the circle mark on the outer sleeve is lined up with the posterior tibial artery located posterior to the medial malleolus of the ankle.

We recommend taking BP at the posterior tibial artery of the lower limb using an electronic BP monitor (oscillometric method). Care should be taken because BP cannot be correctly measured unless the circle mark on the outer sleeve is aligned with the posterior tibial artery, as shown in Fig.

1. The posterior tibial artery is located posterior to the medial malleolus (Fig. 2). The pulse can be felt here by careful palpation in this area.

See Q12-2, Q12-3.



Fig. 1



Fig. 2

6. Measuring and evaluating blood pressure

Q6-2: How accurate is BP measurement obtained at the posterior tibial artery using an electronic BP monitor?

- From a study of surgical cases, we have established that BP measured at the posterior tibial artery using an S size cuff is broadly accurate.

In 2012, we encountered a thalidomide-impaired patient without upper limbs who underwent general anesthesia together with epidural anesthesia. After entering the operating room, BP was measured every 5 minutes during surgery using a home BP measuring cuff (Terumo Corporation, S size 13 cm, 17-26 cm arm circumference) on the left leg (Fig. 3). A BP monitoring cuff that is part of the anesthesia apparatus (Nihon Kohden Corporation, 10 cm for children, arm circumference 15-23 cm) was attached to the right ankle, while arterial pressure was simultaneously invasively monitored using the dorsal artery of the right foot (Fig. 4).

For systolic BP, invasively measured arterial pressure tended to be about 10 to 20 mmHg lower than non-invasively measured BP, although both measurements showed almost identical fluctuations. The difference between BP using the oscillometric method and that by invasive measurements is believed to be about 5 mmHg, with systolic BP being lower and diastolic BP being higher in oscillometric measurements. BP in the upper and lower limbs is also said to be almost identical when measured by arterial line insertion. The differences seen in our patient were attributed to the differences between the invasive and non-invasive measurement methods.

From these results, we concluded that BP measured with an S size cuff that is suitable for the ankle circumference is broadly accurate.

Fig. 3



Fig. 4



Q6-3: Assuming there are differences between lower limb and upper limb BP using indirect measurement methods, is there a formula for estimating upper limb BP from BP measured in the posterior tibial artery?

- **When lower limb BP has been measured using an M size cuff, upper limb BP can be estimated as $0.88 \times (\text{lower limb BP} + 8)$.**

We investigated whether upper limb BP can be estimated from lower limb BP in normal people. The ankle-brachial index is 0.9 to 1.3 in normal people, but when searching MEDLINE, we could not find a regression formula for estimating upper limb BP from lower limb BP. We, therefore, derived a regression formula for estimating upper limb BP from lower limb BP, using data from 1892 people in the 1999-2000 National Health and Nutrition Examination Survey (NHANES), an American survey that publishes analytical data, including upper and lower limb BP measurements. As a result, we obtained the formula 'upper limb systolic BP = $0.88 \times \text{lower limb systolic BP}$ '.

We then investigated the validity of this estimation formula in 17 thalidomide-impaired patients who had been examined and for whom upper and lower limb data were available. As can be seen in Fig. 5, the estimation formula fit the data comparatively well, and we currently recommend using this formula to evaluate upper limb BP. We, however, discovered that systolic BP was being underestimated by 8 mmHg when using an M size cuff on the lower limb compared to an S size. Hence, when measuring BP in the lower limb using an M size cuff, the original systolic BP in the upper limbs is calculated by the formula:

$$0.88 \times (\text{lower limb BP} + 8).$$

Caution is needed in patients with pronounced hardening of the arteries and peripheral arterial disease (PAD), because measured BP decreases and is difficult to evaluate accurately in these patients.

6. Measuring and evaluating blood pressure

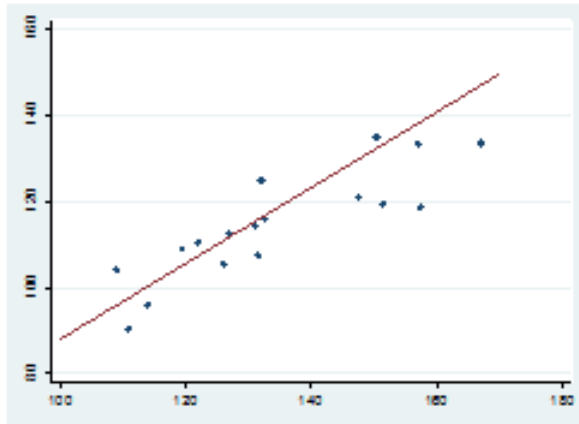


Fig. 5 Relationship between upper and lower limb systolic BP in thalidomide-impaired patients
The horizontal axis shows lower limb BP, the vertical axis shows upper limb BP, and the red line shows the estimation formula 'upper limb systolic BP = $0.88 \times$ lower limb systolic BP'.

Q6-4: Can BP be measured in the upper limb in people with upper limbs that are underdeveloped but not completely missing?

- If the upper arm circumference is less than 24 cm, it is preferable to measure BP using a child's cuff or S size cuff.

The BP monitoring cuff must be of a size that fits the circumference of the patient's limb. Many people with upper limb reduction defects have had their BP measured at the upper limb, but the standard size (M size) BP monitor is intended for people with an upper arm circumference of 24 to 32 cm. It is, therefore, possible that BP measured using an M size BP monitor in patients with an upper arm circumference less than 24 cm will be underestimated. If the upper arm circumference is 17 to 26 cm, it is preferable to measure BP using a child's cuff or S size cuff to suit this circumference.

Q6-5: How should BP be evaluated in people suspected of having peripheral artery disease (PAD)?

- If a difference is suspected between BP in the left and right lower limbs, the systolic BP in the dorsal artery of the foot and the posterior tibial artery should be measured using a Doppler blood flow meter, with an upper arm cuff wrapped around the ankle.

If PAD is present, it is difficult to estimate systemic BP from the measured value in the stenotic artery of the lower limb. It is also possible that the arteries of both the lower limbs could be affected by stenosis. This makes it difficult to measure BP. It is, therefore, very important for

6. Measuring and evaluating blood pressure

thalidomide-impaired patients to prevent hardening of the arteries.

In patients with diabetes, cardiovascular disease, etc., BP would ideally be measured in all four limbs, but in people without upper limbs, BP can only be measured in the lower limbs, and ankle-brachial pressure index (ABI) cannot be measured in this group. It should, therefore, be confirmed that there are no differences in BP between the left and right lower limbs. If a difference is detected, the femoral and popliteal arteries should be palpated to confirm whether the pulse is stronger in the left or right lower limb.

If a difference is suspected between BP in the left and right lower limbs, the systolic BP of the dorsal artery of the foot and the posterior tibial artery should be measured using a Doppler blood flow meter, with an upper arm cuff wrapped around the ankle. The higher value should be taken as the lower limb BP, and differences between left and right sides should be checked. If a Doppler blood flow meter is unavailable, it may be possible to measure systolic BP by using a stethoscope to listen to the pressure at the posterior tibial artery or dorsal artery of the foot. However, BP cannot always be assessed by auscultation in cases of PAD, and PAD, therefore, cannot be ruled out using this method.

Q6-6: Are there any home BP measurement methods that can be used without family assistance?

- **BP can be measured by wrapping the cuff around the limb while seated, then lying on your back and pressing the measurement button with your toe.**

The procedure for measuring BP at home without assistance is as follows.

1. Sit down and lightly wrap the cuff around the top of the ankle joint
2. Position the 'o' mark on the outer sleeve so that it is in line with the posterior tibial artery
3. Lie on your back and remain resting for 2 to 3 minutes
4. Raise your head only and push the start button using the big toe of the other foot.
5. Check the results

The equipment needs to have buttons large enough to be easily operated by the toes, and should have a cuff that can be easily wrapped around the limb using only the feet. Some patients have reported that they find the Smart Mini upper arm UA-621 BP monitor made by A&D Co., Ltd. easy to use.