



Linear Inflation Technology Non-invasive Blood Pressure Measurement

iNIBP Case Report – Experiences in OR



Fighting Disease with Electronics



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Introduction

iNIBP is Nihon Kohden's new non-invasive blood pressure measurement algorithm using linear inflation technology. This case report, which describes the perioperative use of iNIBP, is designed to help clinicians and healthcare professionals understand and appreciate the performance characteristics of iNIBP, including the advantages and limitations of the measurement.

Technology Description of iNIBP

◆ iNIBP advantages

Non-invasive blood pressure (NIBP) is commonly used as an important vital sign to evaluate patients' hemodynamic status. In the traditional oscillometric NIBP measurement using the conventional step-deflation method, a cuff placed on the patients' limb is rapidly inflated to a target pressure greater than systolic, and then deflates step-wise while sensing the oscillations of the arterial wall created by pulsatile blood flow through the artery. On the other hand, iNIBP inflation method completes the measurement while inflating a cuff. Therefore, when compared to the conventional method, the iNIBP measurement time is shorter (Figure 2) and target inflation pressure is lower¹, maximizing patient comfort while preserving the accuracy of this important parameter.

The conventional step-deflation method sets the target inflation pressure based on the previous systolic blood pressure (SYS). When the patient's blood pressure increases compared to previous measurements, the target inflation pressure may be set to a level which is insufficient for the measurement. In these cases, another inflation-deflation cycle is required, and may be repeated, increasing both the measurement time and potential for patient discomfort (Figure 3.a). When the patient's blood pressure has dropped since the previous measurement, the target inflation pressure is set significantly above the previous systolic pressure, which again leads to longer measurement time and excessive pressure applied to the patient (Figure 3.b). With iNIBP technology from Nihon Kohden, the algorithm effects a slow inflation of a cuff while simultaneously detecting oscillations, then deflates the cuff as soon as SYS is determined.

The advantages of iNIBP are best demonstrated when patient's blood pressure is varying, for example during surgery. As iNIBP inflates while sensing blood pressure variation, it can complete the measurement in a shorter amount of time without applying excessive and unnecessary pressure to the patient.

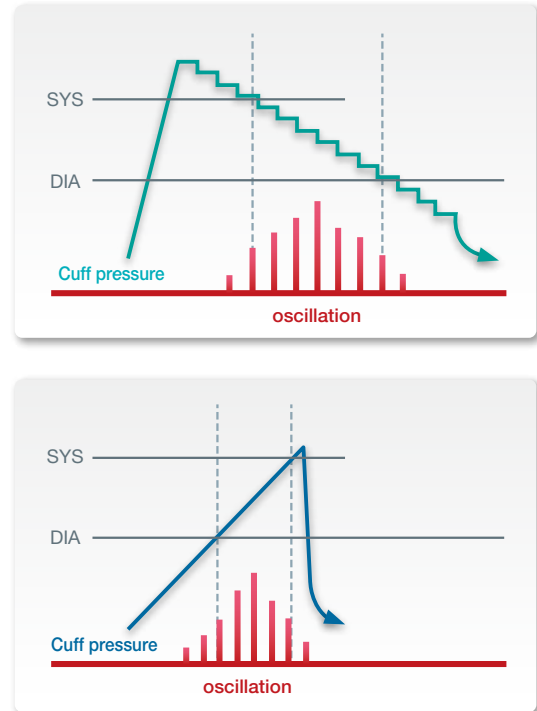


Figure 1 Comparison of the iNIBP inflation method to the conventional deflation method

(Upper) The conventional step-deflation method: A cuff is rapidly inflated to a target inflation pressure, and then deflated step-wise while sensing oscillations.

(Lower) iNIBP inflation method: A cuff is slowly inflated to a lower inflation pressure while simultaneously sensing oscillations.

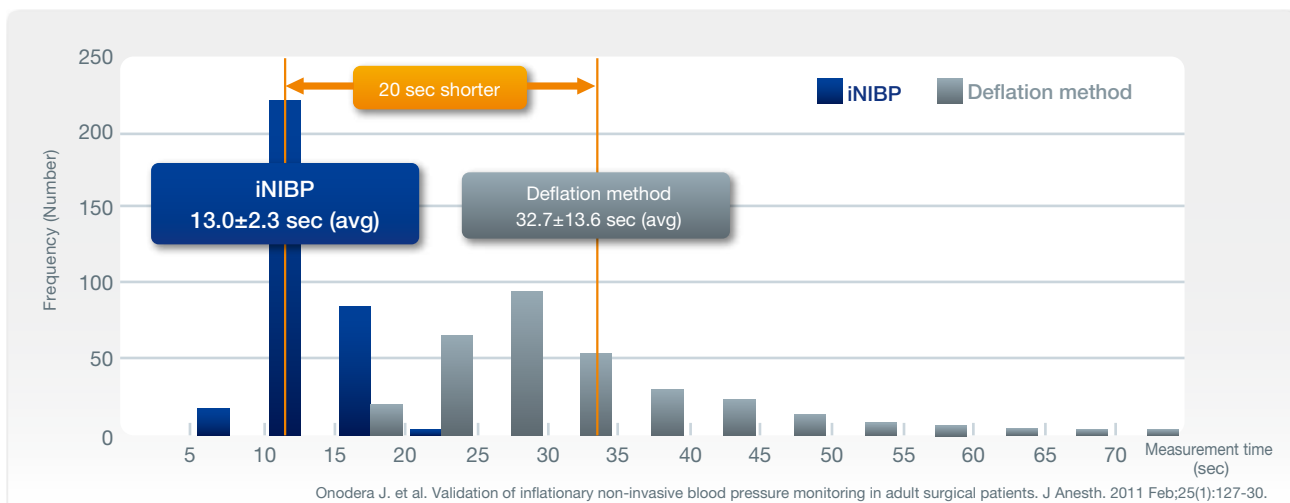
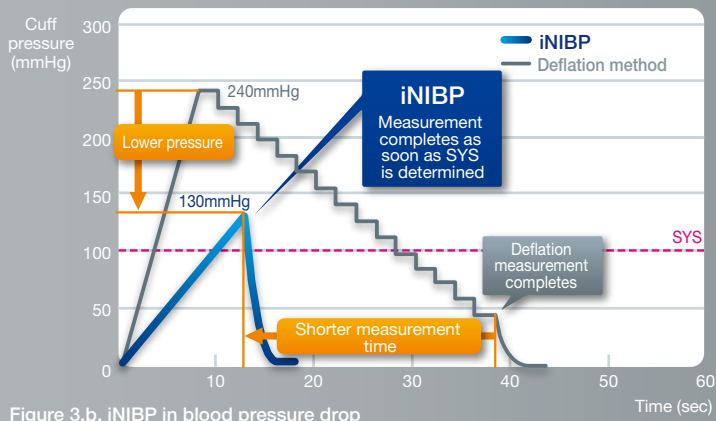
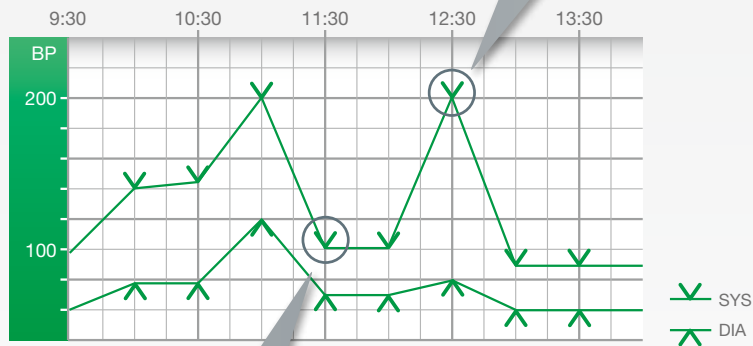
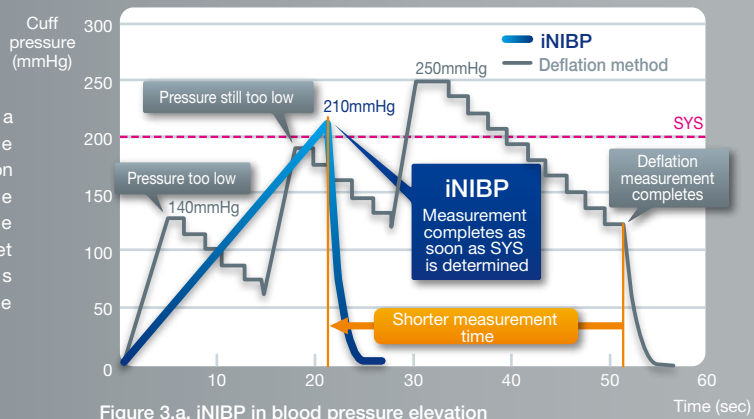


Figure 2 Histogram of measurement time of iNIBP inflation method and deflation method

323 measurement data collected in 64 cases in operating room were used to compare measurement time of iNIBP inflation method and conventional deflation method.

SYS elevated to 200 mmHg

iNIBP can complete the measurement in a shorter amount of time as it inflates the cuff while sensing blood pressure variation and detecting oscillations, whereas the deflation method needs to repeat the inflation-deflation cycle when the target inflation pressure, based on previous systolic pressure measurements are comparatively low.



SYS dropped to 100 mmHg

iNIBP inflates the cuff to only slightly above the SYS while detecting oscillations and completes the measurement in a shorter amount of time, in comparison with the deflation method, which inflates a cuff based on a pre-determined target pressure that often significantly exceeds actual SYS, leading to longer measurement times with the increased potential for patient discomfort.

Figure 3 iNIBP in elevation and drop in blood pressure

◆ iNIBP technology adapts to each patient situation and condition

iNIBP automatically switches its measurement mode to step-deflation in situations where it cannot determine an accurate blood pressure value with inflation method because of factors related to measurement environment and patient's physiology. Also, iNIBP automatically employs the deflation method when signal reliability of the blood pressure reading, based on the blood pressure determined while inflating, is poor (Figure 4). Examples of these situations and conditions are shown below. When these conditions improve, iNIBP will change the mode to the inflation measurement method. Based on the analysis of actual clinical data, about 80% of measurements in the Operating Room (OR) and 70% of measurement in the Emergency Room (ER) were performed with the inflation measurement method².

Factor related to measurement environment

- Cuff and/or tube are not secure and stable because of body motion or contact with the cuff/tube
- Cuff is either too tight or too loose
- Non-recommended cuff or an older cuff with worn Velcro® is used
- Improperly sized cuff for the patient
- Cuff placed over thick clothing

Factor related to patient's physiology

- Frequent arrhythmia
- Patient has weak pulsation due to shock or has extremely low blood pressure (SYS lower than 60 mmHg or DIA lower than 30 mmHg)
- Patient has pulse waves with low amplitude (small pulse wave)
- Slow pulse rate

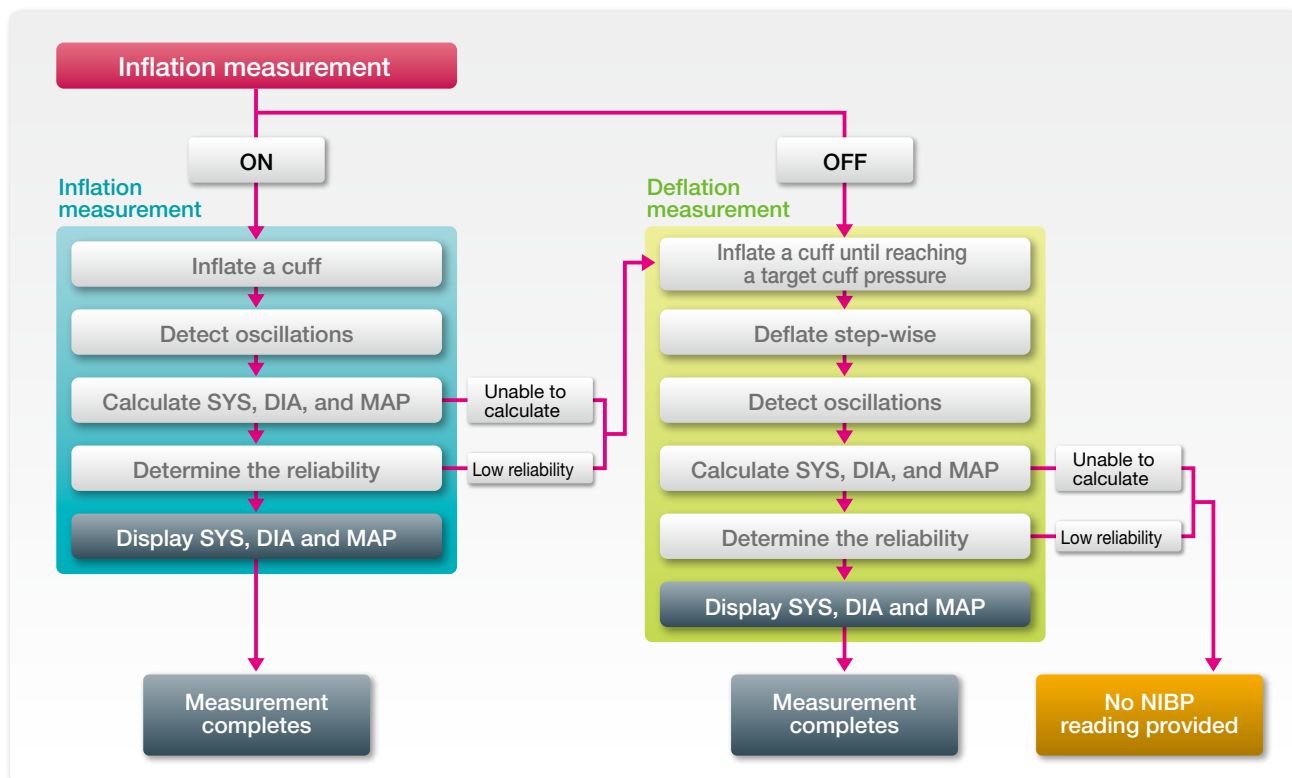


Figure 4 Measurement flow of linear inflation technology non-invasive blood pressure measurement – iNIBP

[Case 1] Laparoscopic assisted distal gastrectomy

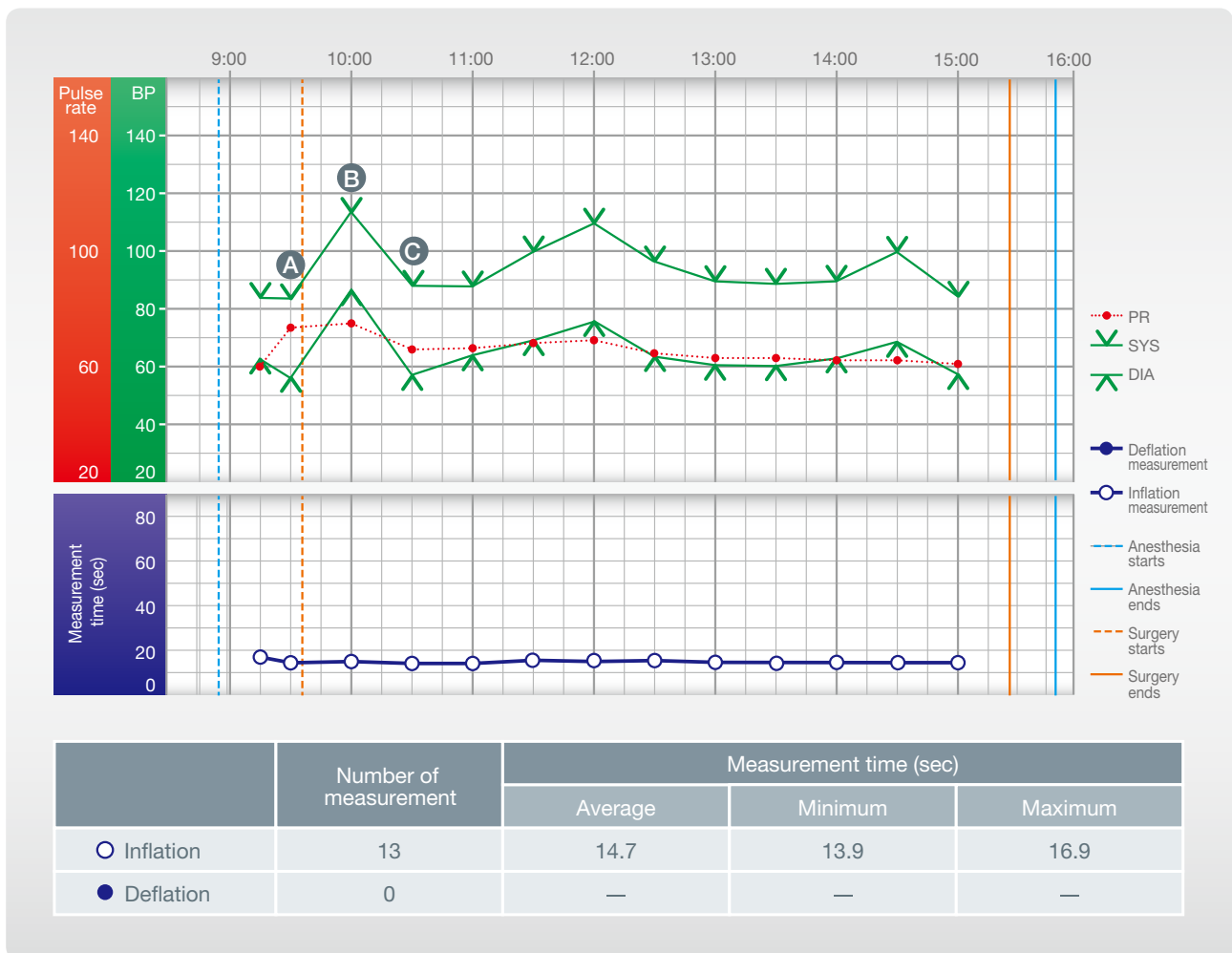
Disease : Stomach cancer

Anesthesia : General anesthesia with epidural block (volatile anesthetic)

Patient : 68 years old male, height 170 cm, weight 81 kg. Cuff on left arm

Anesthesia time : 8:55 – 15:50

Surgical time : 9:37 – 15:25



In this case, a minimally-invasive procedure was performed. Blood pressure increased approximately 30 mmHg between the second (A) and third (B) NIBP measurement, then decreased 25 mmHg between the third (B) and fourth (C) measurement. In cases such as this where blood pressure varies significantly, the conventional deflation method is more likely to repeat the inflation-deflation cycle or set the target inflation pressure too high, leading to longer measurement times. This case shows that iNIBP successfully completed all measurements with the inflation measurement method even in a patient with significant blood pressure variation within a short measurement time.

[Feedback from anesthesiologist]

"I'm curious if NIBP will perform in patients with arrhythmia (e.g. AF, bigeminy or trigeminy). The iNIBP measurement time appears to be shorter compared to the conventional method when used in patients with normal sinus rhythm."

[Case2] Pelvic lymphadenectomy, para-aortic lymphadenectomy

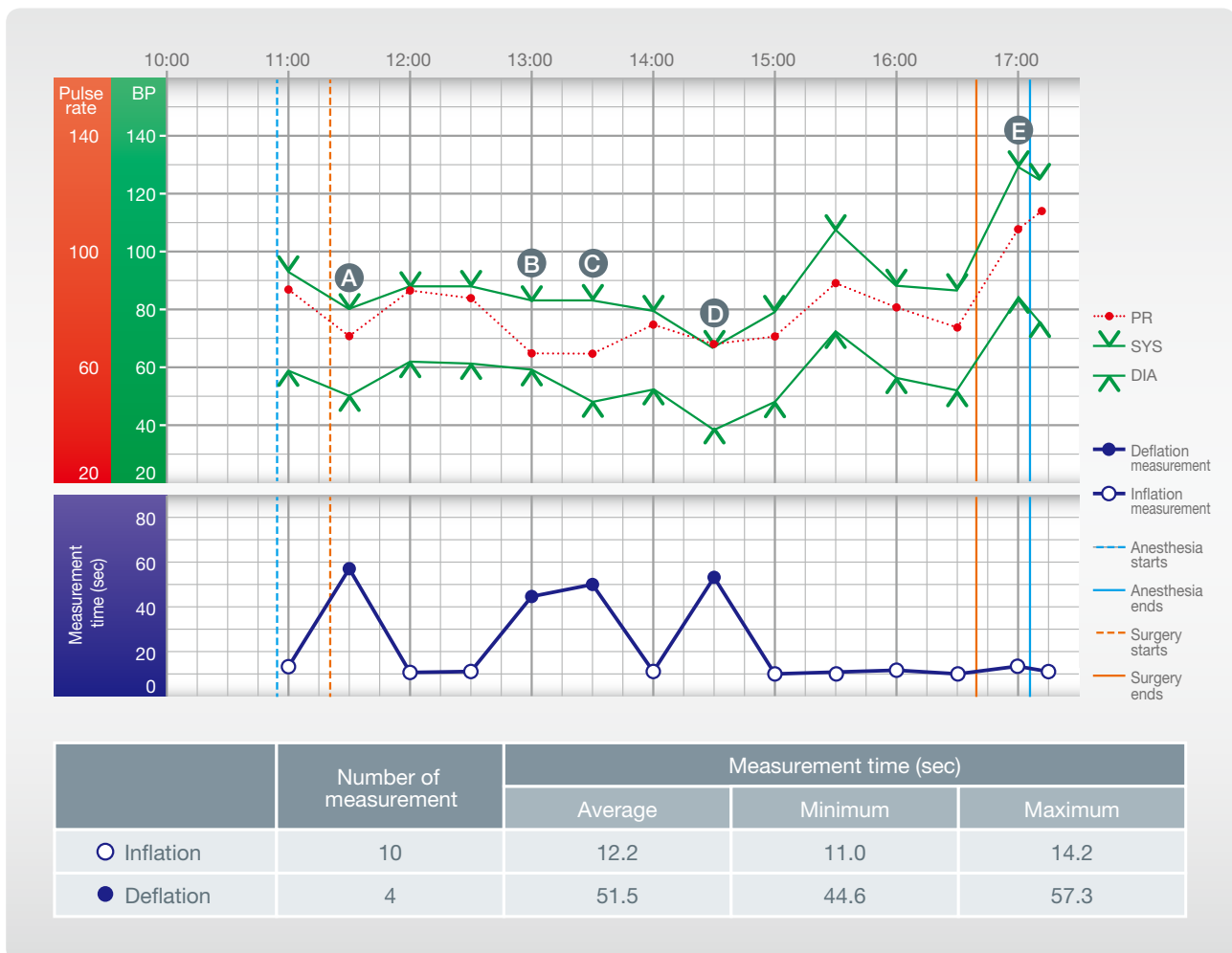
Disease : Ovary cancer

Anesthesia : General anesthesia with epidural block (volatile anesthetic)

Patient : 47 years old female, height 161 cm, weight 56 kg. Cuff on left arm

Anesthesia time : 10:55 – 17:06

Surgical time : 11:21 – 16:39



In the first half of the surgery (beginning of surgery until approximately 14:30), the cuff frequently detected noise caused by touching the cuff, so the iNIBP algorithm did not determine blood pressure while inflating the cuff and switched its measurement mode to the deflation method (A B C and D). As shown in this case, iNIBP automatically changes its measurement mode depending on the situation in order to provide reliable readings.

This case also shows that iNIBP can complete the measurement with the inflation method in a shorter period of time in cases when the patient's blood pressure increases to 43 mmHg (E), where the conventional method will require repetitive inflation-deflation cycles.

[Feedback from anesthesiologist]

"The measurement time of iNIBP did not appear to be significantly shorter compared to the conventional method."

[Case3] Laparoscopic resection of descending colon

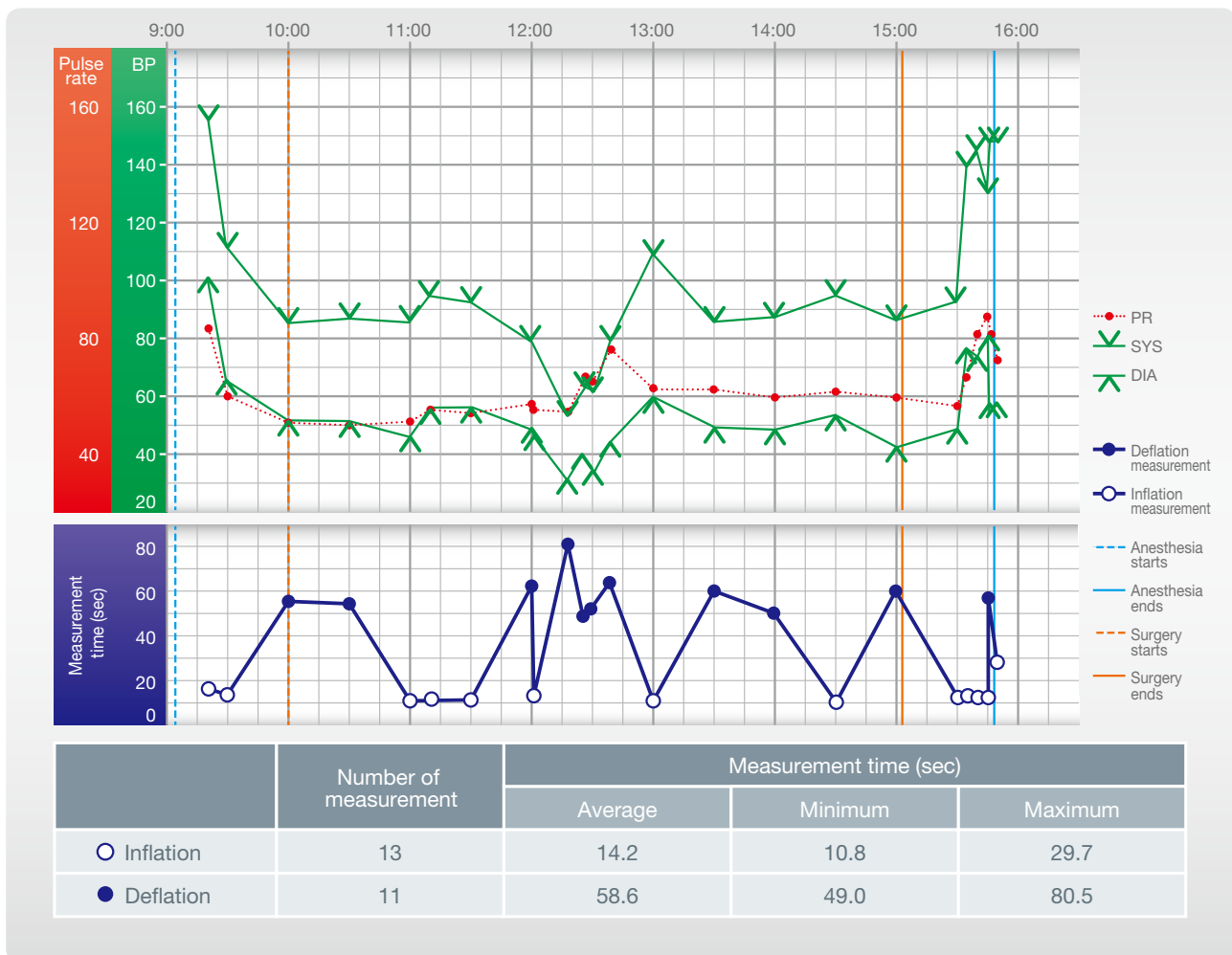
Disease : Descending colon cancer

Anesthesia : General anesthesia with epidural block (volatile anesthetic)

Patient : 72 years female, height 151 cm, weight 74.5 kg. Cuff on left arm

Anesthesia time : 9:05 – 15:49

Surgical time : 10:00 – 15:03



The patient had low amplitude pulse wave and her blood pressure was relatively low (SYS 60-90/DIA 30-50 mmHg) during surgery. When the amplitude of oscillations is lower than a threshold, where it cannot determine an accurate blood pressure value with inflation mode, iNIBP determines NIBP value with the deflation measurement mode instead of the inflation mode. In this case, the amplitude of patient's pulse wave frequently ranged about the threshold, so iNIBP provided half of the readings with the deflation method. However, iNIBP completed the measurement in a shorter period of time with the inflation method even when blood pressure dropped immediately after the anesthesia induction and when blood pressure elevated after the end of surgery and at awakening of the patient.

[Feedback from anesthesiologist]

"It appears that the iNIBP measurement time was half the conventional NIBP measurement time."

[Case4] Radical prostatectomy

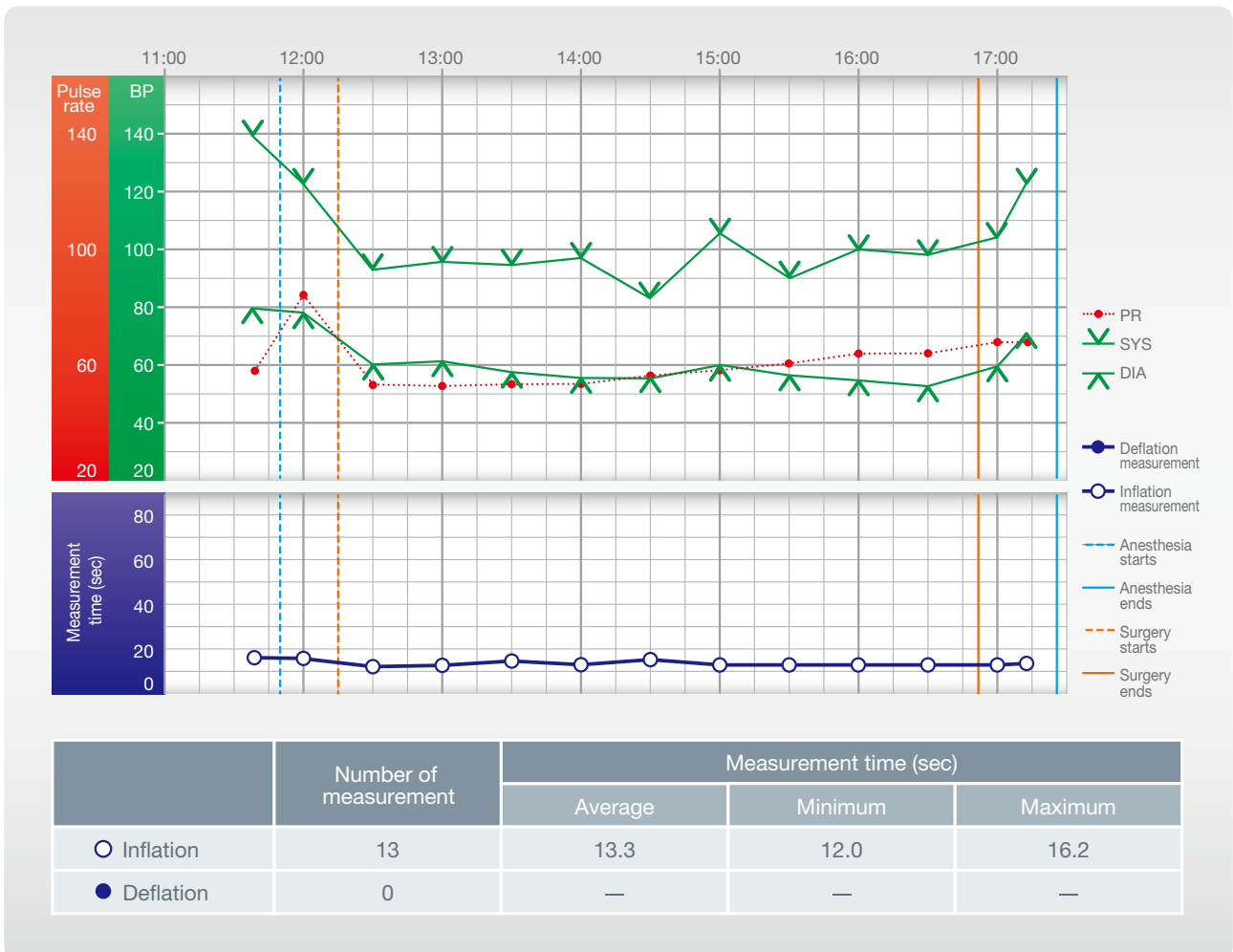
Disease : Prostate cancer

Anesthesia : General anesthesia with epidural block (volatile anesthetic)

Patient : 65 years old male, height 168 cm, weight 68 kg. Cuff on left arm

Anesthesia time : 11:50 – 17:25

Surgical time : 12:14 – 16:52



In this case, all measurements throughout the surgery, from the anesthesia induction through patient awakening, were performed with the inflation measurement mode under the condition of varying blood pressure.

[Feedback from anesthesiologist]

“I was impressed by the speed of the measurement. iNIBP can be convenient because of the shorter measurement time, which may not be essential.”

[Case5] Laparoscopic uterine myomectomy

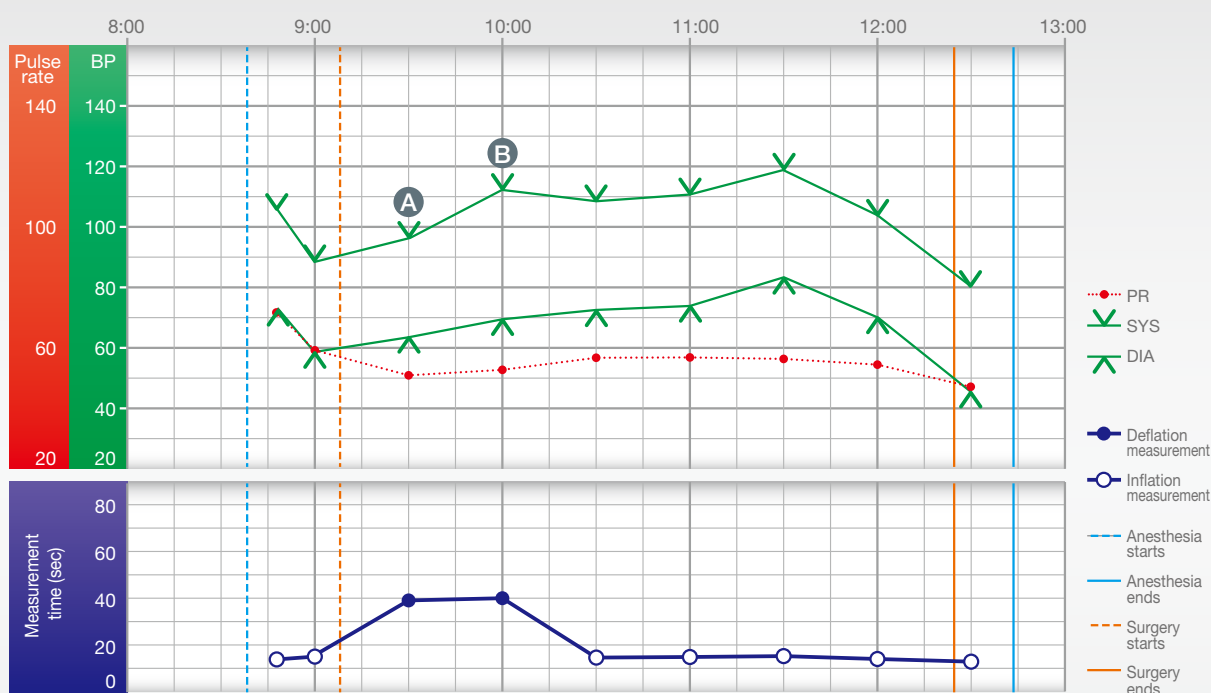
Disease : Uterine myoma

Anesthesia : General anesthesia (volatile anesthetic)

Patient : 37 years old female, height 151 cm, weight 53 kg. Cuff on left arm

Anesthesia time : 8:38 – 12:43

Surgical time : 9:08 – 12:25



| | Number of measurement | Measurement time (sec) | | |
|-------------|-----------------------|------------------------|---------|---------|
| | | Average | Minimum | Maximum |
| ○ Inflation | 7 | 13.9 | 12.8 | 14.6 |
| ● Deflation | 2 | 39.4 | 39.2 | 39.6 |

After the start of the surgery, the deflation method was used for the third (A) and fourth (B) measurement because of noise caused by patient's body motion. Subsequently, iNIBP completed all measurements with the inflation measurement method throughout the surgery. This case demonstrates that iNIBP automatically switches its measurement mode to the step-deflation method in a situation where it cannot determine an accurate blood pressure value with the inflation method due to factors that can affect measurement.

[Feedback from anesthesiologist]

"iNIBP's advantage of being able to measure while inflating allows for shorter measurement time, which can make the measurement more comfortable for patients."

Discussion

Nihon Kohden's Linear Inflation Technology, Non-invasive Blood Pressure Measurement, "iNIBP," determines blood pressure by detecting oscillations during the initial inflation of the cuff. Compared to the conventional method, iNIBP can provide accurate blood pressure readings in less time without applying excessive pressure to the patient, leading to maximized comfort for patients. iNIBP allows clinicians to accurately measure blood pressure immediately and when this critical vital sign is needed the most, especially during dynamic blood pressure changes during surgery.

Nihon Kohden is hopeful that you find this report useful to understand the performance of iNIBP. Please contact us with your ideas and suggestions on how this technology might benefit you and your patients.

Reference

- 1 Jun Onodera, Yoshifumi Kotake et al. Validation of inflationary non-invasive blood pressure monitoring in adult surgical patients. *J Anesth*, 2011;25:127-130.
- 2 Junichi Sasaki, Shingo Hori. Validation of inflationary non-invasive blood pressure monitoring in emergency room patients. Poster presentation at the 34th International Symposium on Intensive Care and Emergency Medicine.

The data shown in this Case Report was provided by Department of Anesthesiology, Toho University Ohashi Medical Center.



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