

Effect of Extracranial Blood Flow on Cerebral Oximetry: A Comparison of Three Cerebral Oximetry devices, NIRO-200NX, INVOS 5100S and TRS

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Abstract

【Background】
Cerebral oximetry using near-infrared spectroscopy (NIRS) is a noninvasive technique used to estimate regional cerebral oxygen saturation (rSO₂). But, the quality of the measurements are uneven among the commercially available cerebral oximetry devices. The absolute values of NIRS were unreliable. NIRS measurement could only report a change from baseline. NIRS values were affected by factors related to optical path length, such as hemoglobin concentration, the differential path length factor, skull thickness, and the area of cerebrospinal fluid layer (1). Recently, it is suggested that rSO₂ measured by the three devices (INVOS 5100C [Covidien; Boulder, USA], FORE-SIGHT [CAS medical system Inc; Brand-ford, CT] and EQUANOX Classic 7600, [Nonin Medical Inc; Plymouth, MN]) is affected by the extracranial blood flow (2). However, other NIRS devices (NIRO-200NX and NIRO-trs [Hamamatsu Photonix; Hamamatsu, Japan]) have not been examined. The purpose of this study was to determine if NIRS guided rSO₂ measurements from these cerebral oximeters, NIRO-200NX and NIRO-trs are able to accurately account for extracranial contamination compared to INVOS-5100.

【Methods】
Fourteen healthy volunteers had three NIRS devices (INVOS 5100C, NIRO-200NX and NIRO-trs) randomly applied to the forehead. After this, a circumferential pneumatic head cuff was positioned such that when inflated by MIZUHO MT880 Digital tourniquet (Mizuho Medical Innovation, Tokyo, Japan), hypoxia-ischemia would be produced in the extracranial scalp tissue beneath the NIRS cerebral oximeters. Cessation of blood flow to the extracranial tissue, and therefore induction of local scalp tissue hypoxia-ischemia was confirmed by a loss of forehead SpO₂ (MAX FAST, Covidien, Boulder, USA) signal (fig1). Extracranial hypoxia was established, the head cuff remained inflated for 5 min, following this, the head cuff was deflated, allowing the superficial tissues to be re-perfused for 5 min. rSO₂ and other physiologic measurements recorded every 1 min during 5 min of inflation and 5 min of deflation.

【Results】
The induction of extracranial hypoxia-ischemia resulted in a significant reduction in rSO₂ measurements by INVOS (66.1 ± 9.1 → 56.3 ± 9.5, p < 0.001). But other two devices did not show significant changes, [NIRO200 (TOI: 64.9 ± 9.4 → 60.8 ± 9.5, p = 0.20), NIRO-trs (ScO₂: 61.8 ± 8.1 → 58.9 ± 6.9, p = 0.12)] (fig2).

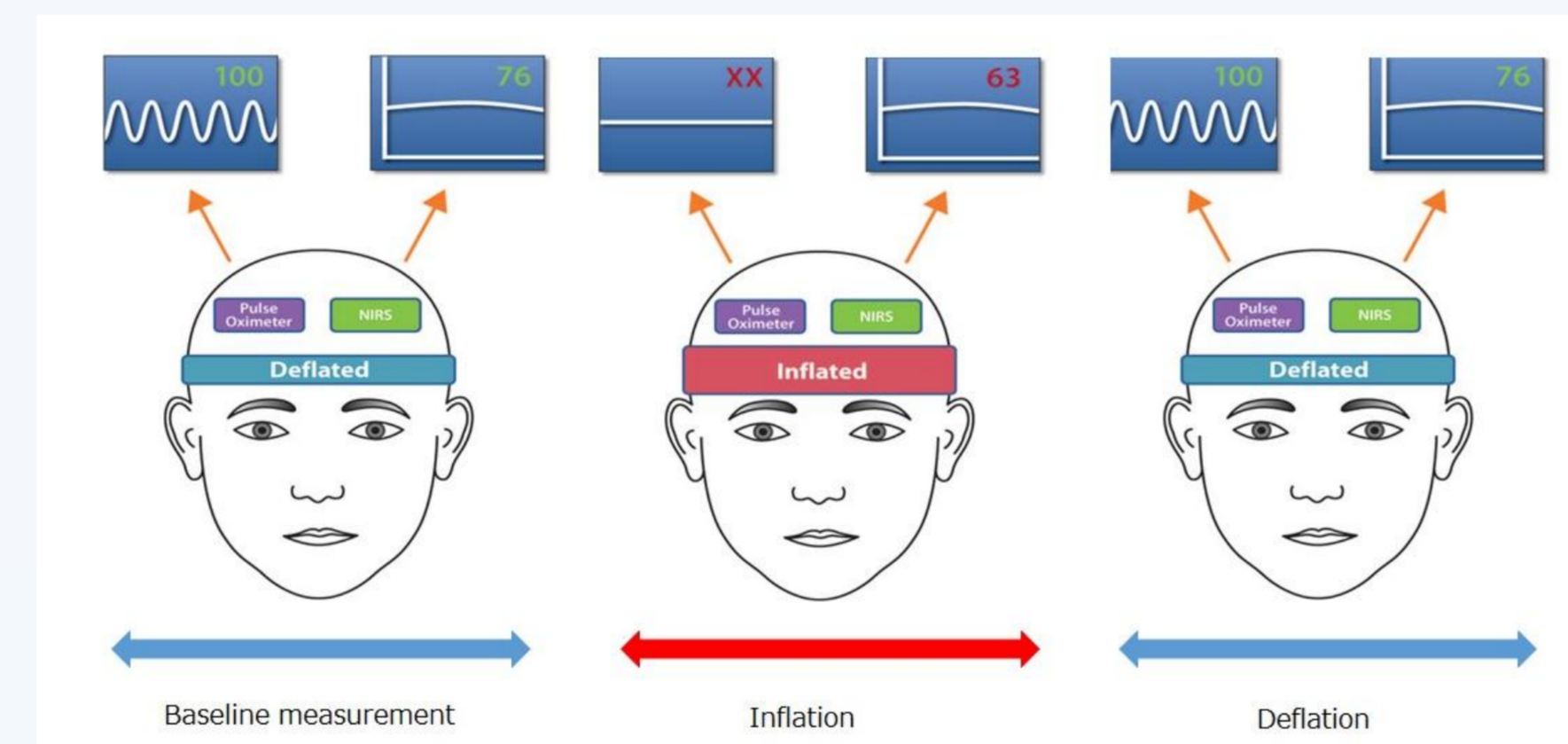
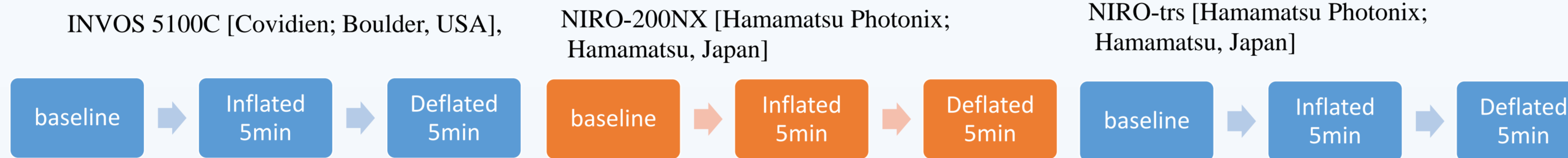
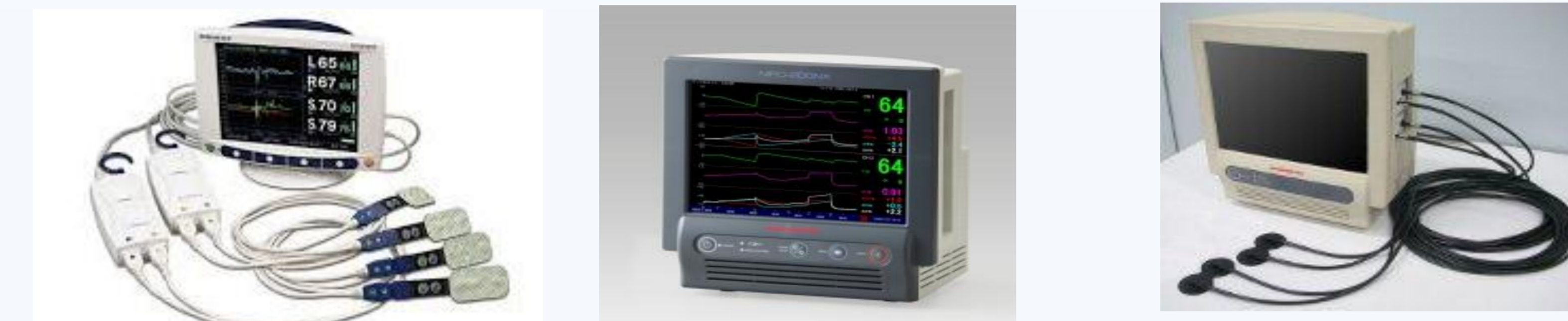
【Conclusions】
rSO₂ measured by INVOS was influenced by extracranial contamination. This study indicated that the measurements of rSO₂ by INVOS included the extracranial cerebral blood flow.

【References】
(1)Yoshitani K, Kawaguchi M, Miura N, et al. Anesthesiology. 2007 Mar;106(3):458-62
(2)Davie SN, Grocott HP. Anesthesiology. 2012 Apr;116(4):834-40.

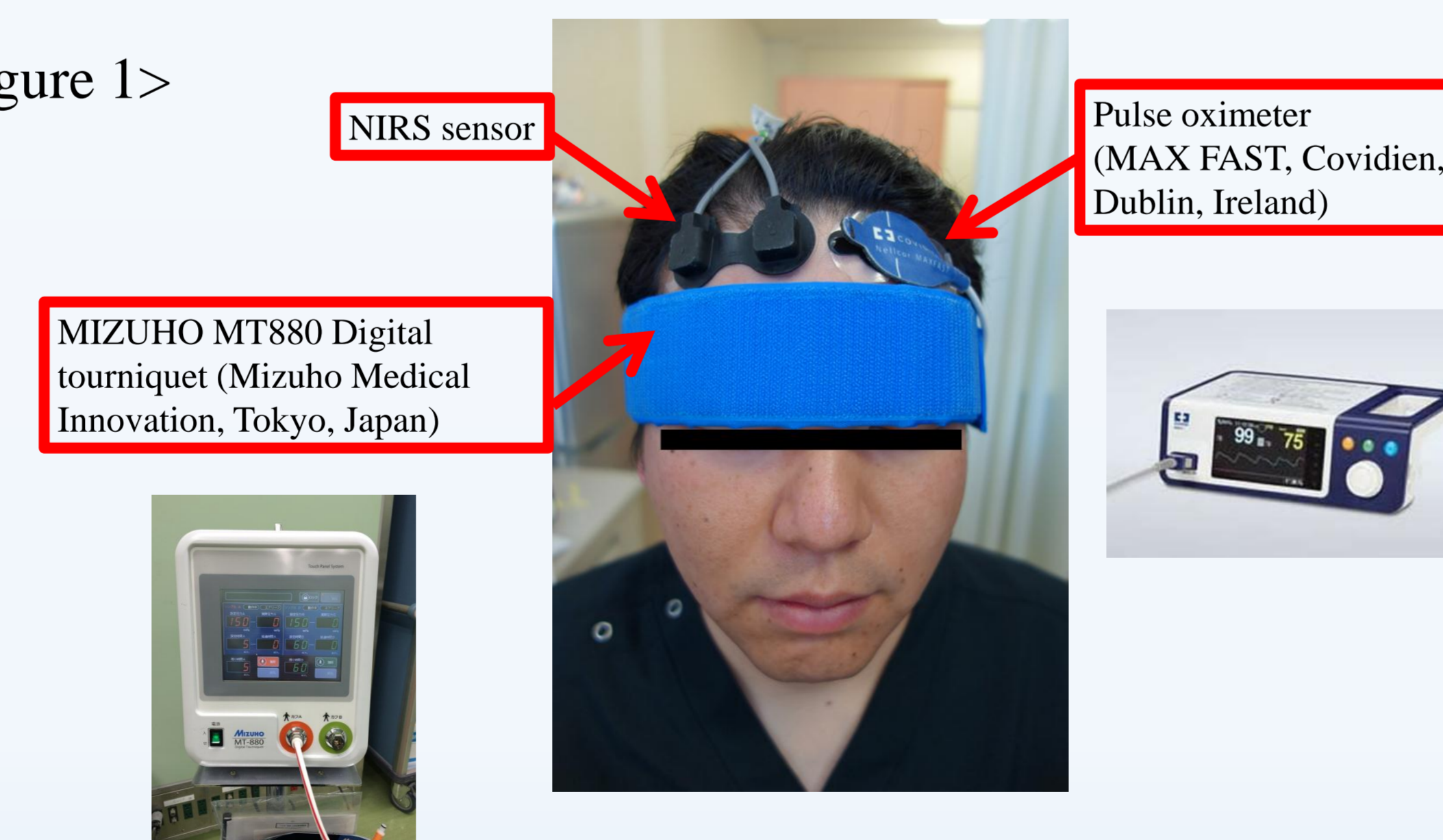
Introduction

- Cerebral oximetry using near-infrared spectroscopy (NIRS) is a noninvasive technique used to estimate regional cerebral oxygen saturation (rSO₂).
- But, the quality of the measurements are uneven among the cerebral oximetry devices.
- NIRS values were affected by factors related to optical path length, such as hemoglobin concentration, the differential path length factor, skull thickness, and the area of cerebrospinal fluid layer (1).
- Recently, it is suggested that rSO₂ measured by the three devices (INVOS 5100C , FORE-SIGHT and EQUANOX Classic 7600,) is affected by the extracranial blood flow (2).
- The purpose of this study was to determine if NIRS guided rSO₂ measurements from these cerebral oximeters, NIRO-200NX and NIRO-trs are able to accurately account for extracranial contamination compared to INVOS-5100.

Methods



<figure 1>

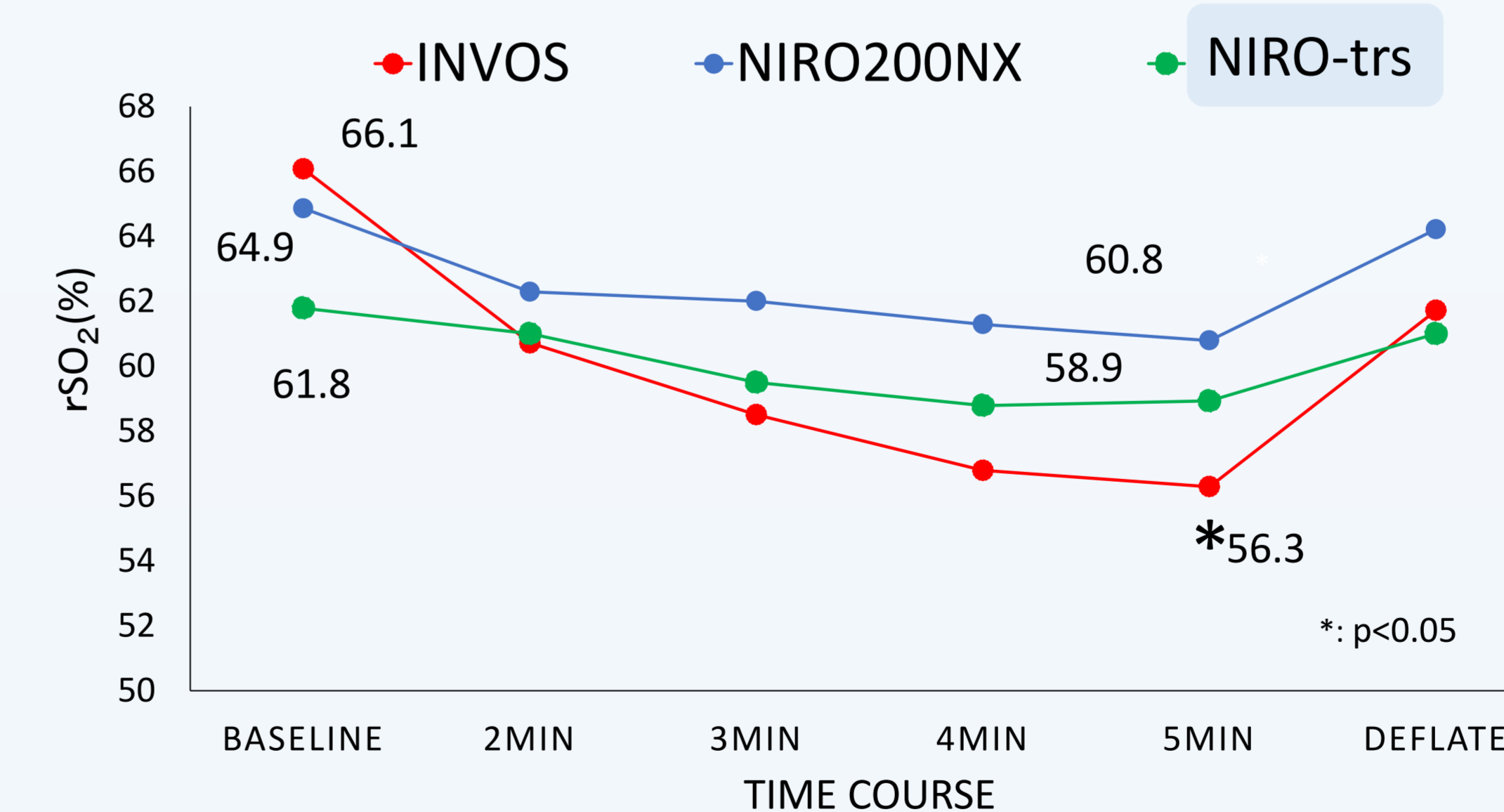


Results

● Physiologic Results

		Baseline	inflated 5min	deflated 5min	P value (variation between subgroup)
HR (bps)	INVOS	70 ± 7	67 ± 9	67 ± 8	0.682
	NIRO	68 ± 7	66 ± 6	66 ± 8	
	TRS	66 ± 9	65 ± 9	65 ± 7	
MAP (mmHg)	INVOS	81 ± 10	79 ± 10	79 ± 7	0.615
	NIRO	77 ± 10	76 ± 9	77 ± 10	
	TRS	78 ± 8	82 ± 10	80 ± 8	
SpO ₂ (%)	INVOS	99 ± 1	99 ± 1	98 ± 1	0.962
	NIRO	99 ± 1	98 ± 1	99 ± 1	
	TRS	98 ± 1	98 ± 1	98 ± 1	

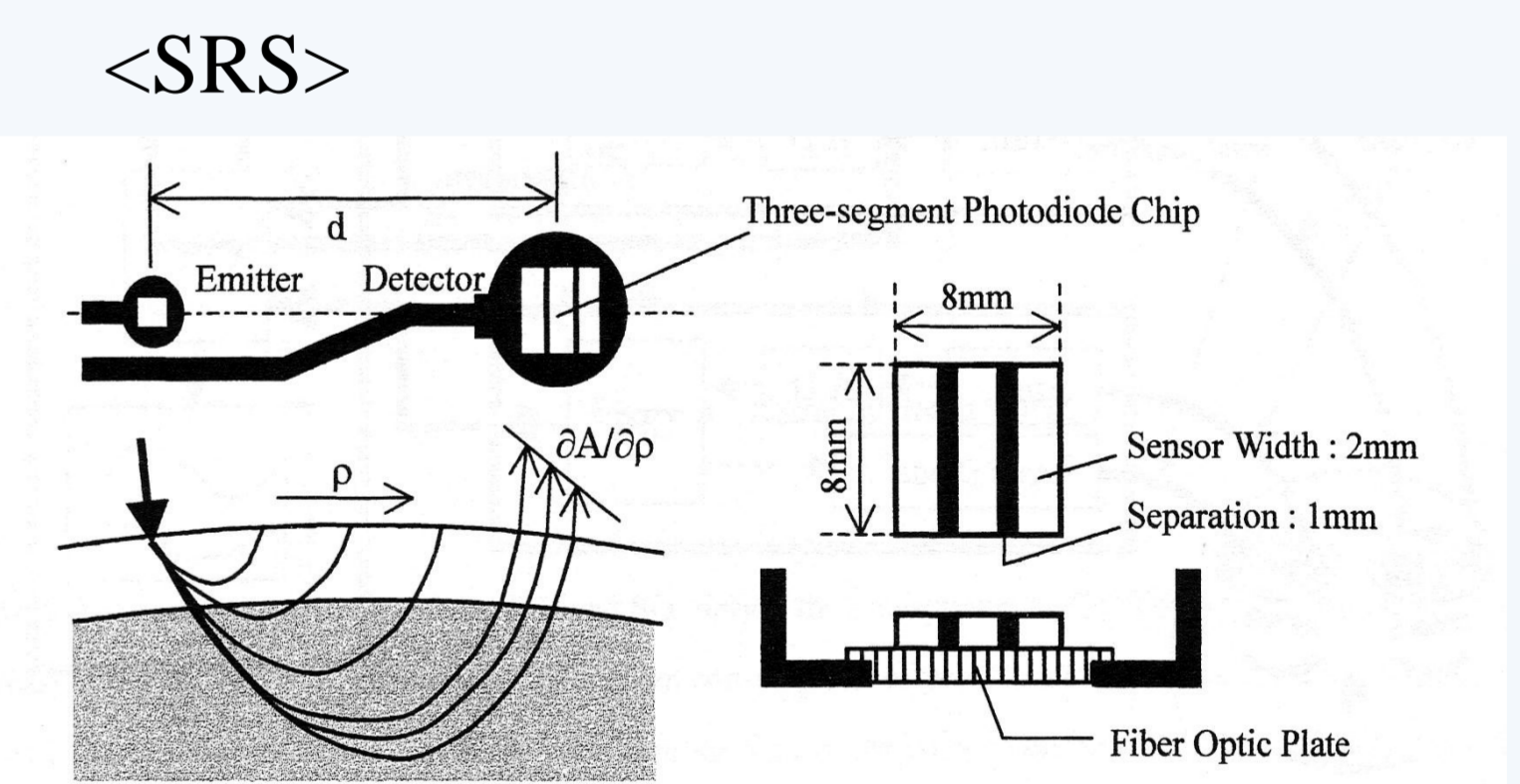
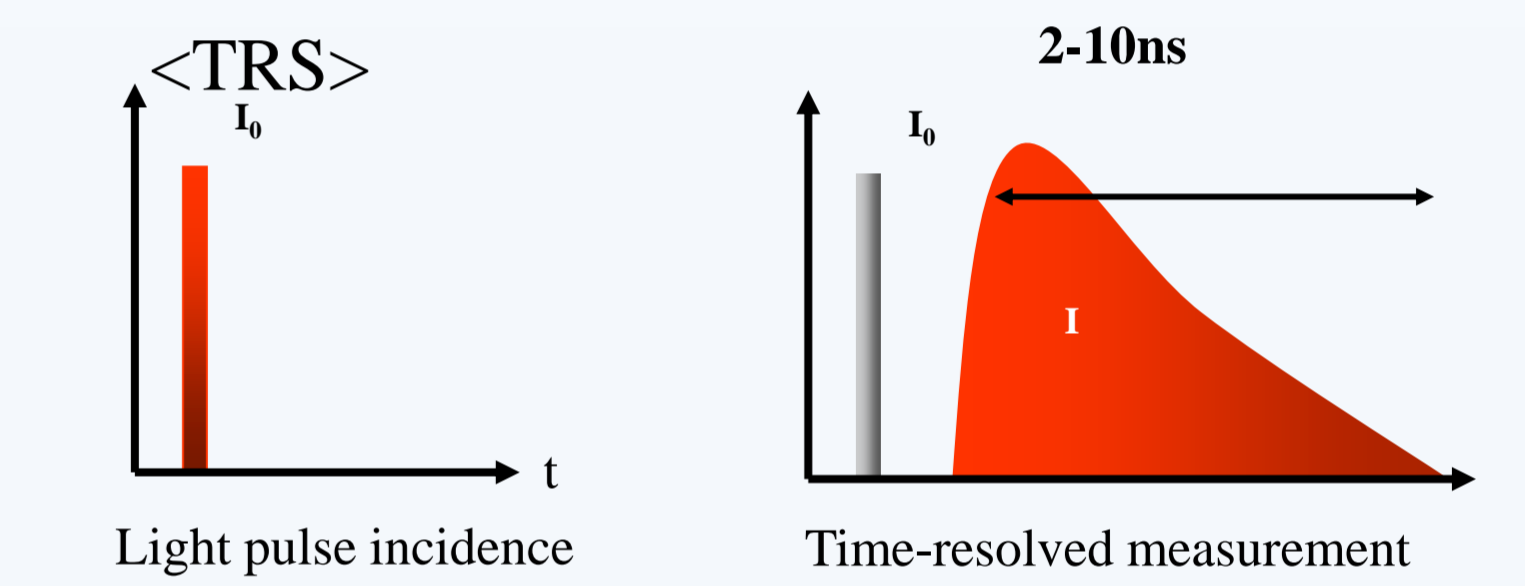
● Time Course of Change of rSO₂ <figure 2>



Discussion

- INVOS was significantly affected by the extracranial blood flow, but NIRO and NIRO-trs were not.
- It was suggested that the measurement of rSO₂ by INVOS did not express the intracranial regional oxygen saturation.
- Algorithm of the measurement of rSO₂ is different in the three devices.

- INVOS : Unknown
- NIRO : spatial resolved spectroscopy
- NIRO trs : time resolved spectroscopy



Conclusion

- Hypoxia-ischemia would be produced by a head cuff in the extracranial scalp tissue beneath the NIRS cerebral oximeters.
- rSO₂ measured by INVOS, not by NIRO and TRS, was influenced by extracranial contamination.
- This study indicated that the measurements of rSO₂ by INVOS included the extracranial cerebral blood flow.
- We need to consider that INVOS values were affected by extracranial cerebral blood flow.

References

- (1)Yoshitani K, Kawaguchi M, Miura N, et al. Anesthesiology. 2007 Mar;106(3):458-62
(2)Davie SN, Grocott HP. Anesthesiology. 2012 Apr;116(4):834-40.

