



[ Original Article ]

## Usefulness of eICU system in pediatric critical care consultation

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### Abstract

**Background:** The complexity of pediatric intensive care unit (PICU) support has increased due to advances in surgical interventions and treatment modalities. The need for the PICU is increasing, but the current number of pediatric intensive care physicians is inadequate to meet the demand. Intensive care unit telemedicine (tele-ICU/eICU) was developed to address the increasing complexity of patient care and the inadequate number of intensivists.

**Methods:** The first eICU system was installed in Tokyo Metropolitan Children's Medical Center (TMCMC) in 2010. This eICU network was developed as a collaborative effort between TMCMC and Tama-Hokubu Medical Center (THMC). A video conference unit was installed in the PICU at TMCMC, and a mobile, pole-mounted telemedicine unit was placed in the pediatric ward at THMC. We analyzed case backgrounds, purpose of usage and efficacy of this eICU system. Also we herein describe the typical case of one patient whose treatment clearly demonstrated the effectiveness of this eICU system.

**Results:** 15 cases (22 events) used eICU were observed during this project period (2011-2013). 6 cases were consultation only, however, 7 cases required inter-hospital transfer, and 4 cases were transferred in emergent fashion. 6 events were used for follow up rounds after discharge. In the typical case, the referral decision was expedited, critical care management improved, and the time required for treatment generally shortened. The improvement in overall critical care management was remarkable.

**Conclusion:** This is the first report describing the usefulness of the eICU system in pediatric critical care field. Network security and privacy protection are foreseen as major obstacles to the use of this program and should be resolved to expand the use of the telemedicine/eICU system throughout Japan.

**Key words:** Tele ICU, Telemedicine, Health services research, Emergency medicine, Critical care medicine, Critical care outreach

### I. Introduction

Pediatric critical care is resource-intensive and demands meticulous process control. The complexity

of pediatric intensive care unit (PICU) support has increased due to advances in surgical interventions and treatment modalities. The need for the PICU is continuously increasing, but the current number of pediatric intensive care physicians, nurses, and co-medical staff in Japan is inadequate to meet the demand.

Intensive care unit telemedicine (tele-ICU, so called eICU) is technology-enabled care delivered from off-site locations and was developed to address the increasing complexity of patient care and the inadequate

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number of intensivists[1]. Tele-ICU/eICU has rapidly expanded in adult ICU treatment, but has lagged behind in the PICU.

In this present study, we developed the first eICU system for children and aimed to evaluate the usefulness of eICU system in pediatric critical consultation.

## II. Materials and methods

The first eICU system was developed as a collaborative effort between TMCCM and Tama-

Hokubu Medical Center (THMC) using a public grant from the Tokyo Metropolitan government and was installed at Tokyo Metropolitan Children's Medical Center (TMCCM) in 2010. A video conference unit was installed in the PICU at TMCCM using four monitors to display the patients' appearance, biological information, radiological images, and selected information from the electronic medical records (data were restricted to protect patients' personal information) (Fig. 1). A mobile, pole-mounted telemedicine unit was placed in the pediatric ward at THMC (Fig. 2).



Fig. 1 Video conference unit at TMCCM



Fig. 2 Mobile, pole-mounted telemedicine unit at THMC

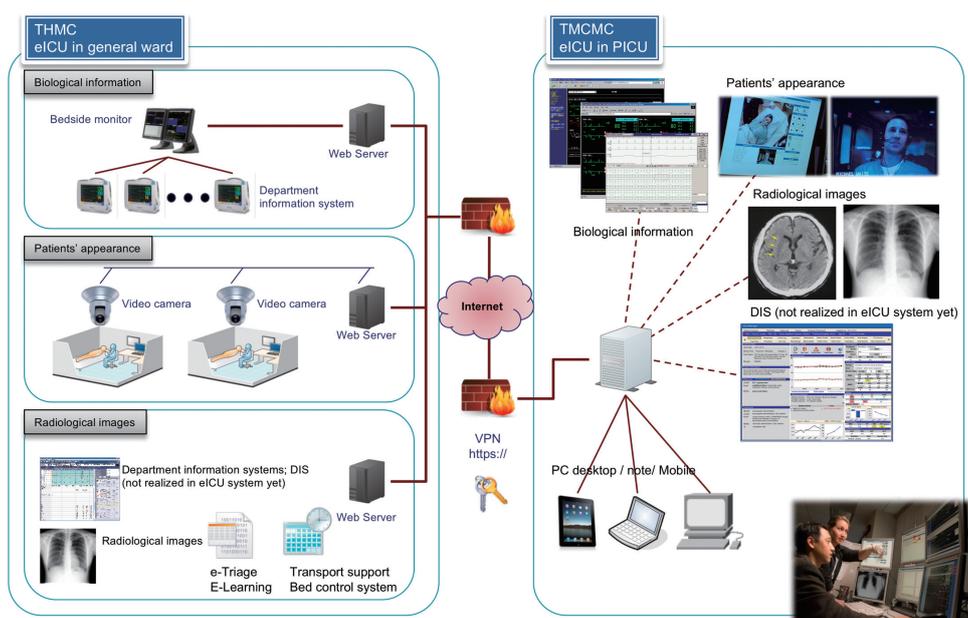


Fig. 3 Schematic diagram of this tele-ICU/eICU system

This system was used to deal with 15 cases (22 events) during the project period (2011-2013). We analyzed case backgrounds, purpose of usage and efficacy of this eICU system. Also we herein describe the typical case of one patient whose treatment clearly demonstrated the effectiveness of this eICU system. This is the first report describing the usefulness of the eICU system in pediatric critical care consultation in Japan.

This study was approved by the ethics board of the Medical Research Committee of TMCMC. Publication of the study was approved by the Institutional Review Board of TMCMC.

### III. Results

15 cases (22 events, 0 months-18 years, mean age 4 months) used eICU were observed during this project period (2011-2013). Case background, purpose of usage and efficacy of eICU was summarized in Table 1. 6 cases (9 events, 41%) were consultation

only, however, 7 cases (7 events, 32%) required inter-hospital transfer from pediatric general ward in THMC to PICU in TMCMC. Within 7 transferred cases, 4 cases were transferred in emergent fashion by the transfer team dispatched from TMCMC. 6 events were used for follow up rounds after the discharge from PICU/NICU in TMCMC to general ward in THMC. Typical case description was as below.

A 2-month-old boy was admitted to the pediatric general ward of THMC due to respiratory difficulty. Bronchiolitis caused by respiratory syncytial virus infection was diagnosed. His respiratory condition deteriorated, and he was intubated by pediatricians at THMC. Consultation was later held via the eICU system in the PICU at TMCMC.

Since the patient had straightforward bronchiolitis, the THMC physicians initially opted to continue treatment at THMC; however, the intensivists at TMCMC decided that the patient should be transferred to the PICU at their institution due to his unstable,

Table 1 Case background, purpose of usage and efficacy of this tele-ICU/eICU system

Event	Case	Age	Diagnosis	Purpose and Efficacy
1	1	1 month	Renal displasia	Consultation only
2	1	1 month	Renal displasia	Consultation only
3	1	4 month	Renal displasia	Consultation only
4	1	5 month	Renal displasia	Consultation only
5	2	18 years	CP, GI tract bleeding	Consultation only
6	3	0 month	Bacterial meningitis	<b>Emergent T/F to PICU</b>
7	3	0 month	Bacterial meningitis	F/U after PICU discharge
8	4	1 year	Prader-Willi syndrome	F/U after PICU discharge
9	5	16 year	Prulent spondylitis	Consultation only
10	6	4 year	Subdural effusion	T/F for surgery and PICU
11	7	4 year	Intra cranial bleeding	T/F for surgery and PICU
12	8	8 year	BA severe attack	<b>Emergent T/F to PICU</b>
13	9	1 month	18 trisomy	F/U after NICU discharge
14	10	2 month	RS virus infection	<b>Emergent T/F to PICU</b>
15	10	3 month	RS virus infection	F/U after PICU discharge
16	10	3 month	RS virus infection	F/U after PICU discharge
17	11	3 month	Cervical LN swelling	Consultation only
18	12	5 year	Prulent arthritis	T/F for surgery and PICU
19	13	7 month	RS virus infection	Emergent T/F to PICU
20	13	8 month	RS virus infection	<b>F/U after PICU discharge</b>
21	14	1 year	Hip joint arthritis	Consultation only
22	15	4 month	Femur fracture	Consultation only

CP: cerebral palsy

T/F: transfer

BA: bronchial asthma

F/U: follow up

RS: respiratory syncytial

NICU: neonatal intensive care unit

nonsynchronized respiratory pattern on the ventilator, which was visualized by the eICU system. A transport team was dispatched from TCMC to receive the patient.

The patient's chest X-ray images were transmitted via the eICU system, and the endotracheal tube (ETT) position was confirmed and adjusted. The dosage of sedative was increased, and the ventilator settings were adjusted to stabilize the patient. Serial changes in his respiratory pattern were monitored via the eICU system. Physicians at TCMC were continuously updated on the patient's status by the transport team during transit using a different communication modality.

Before the transport team arrived to receive the patient, his respiratory condition had improved, and preparation for PICU admission was complete. He was transported successfully and admitted to the PICU at TCMC without further event.

#### IV. Discussion

ICU telemedicine programs now support 11% of critically ill adult patients in private hospitals worldwide. There is increasingly robust evidence of an association between the use of ICU telemedicine programs and lower ICU and hospital mortality and shorter ICU length of stay[2]. The use of telemedicine is increasing and will eventually be common even in remote emergency departments, inpatient wards, and intensive care units for pediatric care[3].

Dharmar et al. reported that physician-rated quality-of-care for children was higher for patients who received consultations via telemedicine than for patients who received either telephone consultations or no consultation at all. Telemedicine consultations for sick children were associated with more frequent changes in diagnostic and therapeutic interventions and higher parent satisfaction than telephone consultations[4].

In the present case, the referral decision was expedited, critical care management (ETT position, sedative dosage, ventilator settings, etc.) improved, and the time required for treatment was generally shortened (prompt dispatch of transport team, swift

admission preparation, etc.) as a result of improved time management. The overall improvement in critical care management was remarkable.

Although many studies have supported the use of telemedicine/eICU, and the facts described in this case report underscore the findings of these studies, several obstacles to the further expansion of eICU remain. The high cost and technical difficulties with the use of the current system are examples of such barriers. However, the reduction in personnel expenses and the superior time-efficiency allowed by the eICU system compensate for its higher cost while the current technical difficulties will doubtless be resolved through improvements in the technology.

Network security and privacy protection are also frequently pointed out as potential problems, and are major obstacles to the expansion of this program in Japan. These issues need to be resolved for the future expansion of the telemedicine/eICU program in Japan.

#### Author contributions

NS conceived and designed the study, collected, analyzed, and interpreted the data. NS, TO, OS, and TI were involved in writing and reviewing the manuscript.

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#### Conflict of interest

The authors declare that they have no conflicts of interest, either financial or non-financial, with the context of this article, except for the public grant from Tokyo Metropolitan.

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