Telegraphic Medicine Systems Improve Medical Diagnosis in Pre-Hospital Settings: A Pilot Study in a Tertiary Care Hospital

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Background: *Non-physician responders mainly provide pre-hospital services or emergency medical service (EMS) in Thailand due to shortage of emergency physicians. There is still high-risk for preventable death during pre-hospital care and transfer. Telegraphic medicine is a promising strategy to solve this problem.*
Objective: *To determine the efficacy of telegraphic medicine systems in EMS during responses by advanced life support teams.*
Material and Method: *This was a pilot study in a tertiary care setting. Telegraphic medicine systems were used in conjunction with advanced life support teams. These systems included video and audio signals, electrocardiograms, and vital signs transmitted from the pre-hospital scene and ambulance to a monitoring room in the hospital. We divided efficacy of telegraphic medicine into four categories, primary diagnosis, proper airway management, proper circulatory management, and proper neurological management. Experienced emergency physicians evaluated appropriateness of treatment in each category.*
Results: *There were 100 pre-hospital emergency patients enrolled in the present study. Twenty-seven patients were randomly assigned to the telegraphic medicine group. Telegraphic medicine systems significantly increased the percentage of cases with primary diagnosis. They also increased the percentages of patients receiving appropriate airway, circulatory, and neurological management, but was not statistically significant.*
Conclusion: *Telegraphic medicine was shown to increase the percentage of patients who received a primary diagnosis, as well as the percentages of those who received appropriate diagnoses, airway, circulatory, and neurological management. Thus, it is a promising system for EMS in Thailand.*

Keywords: *Telemedicine, Tele-health, Pre-hospital, EMS*

J Med Assoc Thai 2017; 100 (6): 686-91
Full text. e-Journal: *http://www.jmatonline.com*

There were 1,215,294 emergency medical service (EMS) responses in Thailand in 2013[1]. Medical teams responsible for treatment included first responder units lead by first responders (FR), basic life support (BLS) units lead by emergency medical technicians-basic (EMT-B), intermediate life support (ILS) units lead by emergency medical technicians-intermediate (EMT-I), and advanced life support (ALS) units lead by pre-hospital emergency nurses (PHEN), emergency medical technician-paramedics (EMT-P), or emergency physicians (EP). Emergency medical dispatch centers in each province had the authority to choose qualified response teams in each pre-hospital medical situation. However, there is shortage of emergency physicians in Thailand. In most circumstances, ALS teams were lead only by PHENs or EMT-Ps. Although PHENs and EMT-Ps have expertise in the emergency field, there are some areas in which physicians are more capable. These are, for example, difficult airway management, electrocardiographic interpretation, and making decisions regarding fluid resuscitation. Hence, to improve EMS, telegraphic medicine systems that allowed emergency physicians to monitor real-time management of ALS teams were initiated at Maharat Nakhon Ratchasima Hospital.

Telegraphic medicine systems were aimed at assisting PHENs and EMT-Ps in ALS when they could not be accompanied by an emergency physician[2]. Telegraphic medicine systems consisted of real-time visual and audio signals that were transmitted from the scene to a monitoring room in the hospital[3,4]. Vital signs and electrocardiography were also transmitted[3].

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The emergency physician in the monitoring room received information about the patient and made treatment decisions in real time. There were two-way communications between the emergency physician and PHENs or EMT-Ps at the scene and during transfer to the target hospitals.

Since telegraphic medicine is a novel system for Thai EMS, we decided to study its efficacy and possible benefits in real-life practice.

Objective

Our primary objective was to determine the efficacy of telegraphic medicine systems in EMS in Thailand during responses by ALS teams.

Our secondary objective was to determine the efficacy of telegraphic medicine systems in ALS teams with and without physician accompaniment.

Material and Method

This study was conducted between October 1, 2014 and March 15, 2015. The setting was a 1,680 bed-hospital in Maharat Nakhon Ratchasima in northeast Thailand. Maharat Nakhon Ratchasima Hospital is a tertiary care hospital with nine emergency physicians. The hospital is responsible for EMS within 10 kilometers radially, which covers the Muang sub-district of Nakhon Ratchasima province. The population of the area is around 190,000.

The hospital's Ethical Committee approved the present trial. Informed consent was obtained from participants prior to enrollment.

Population

Patients who received ALS response from Maharat Nakhon Ratchasima Hospital teams at pre-hospital scenes.

Inclusion criteria

1. Patients who received ALS response from Maharat Nakhon Ratchasima Hospital at pre-hospital scenes.
2. Patients who signed inform consent forms.
3. Patients between 18 and 80 years old.

Exclusion criteria

1. Cardiac arrest patients
2. Incomplete medical records

Sample technique

Simple random sampling of consecutive cases.

Definition

1. Telegraphic medicine systems included multiple types of data transferred from the scenes.

Closed-circuit television transferred real-time video and audio data. Defibrillators transferred real-time blood pressure, pulse rate, oxygen saturation, capnography, and electrocardiography to a monitoring room in the emergency department.

An on-duty emergency physician who was not a member of the investigation team was assigned to control the monitoring room and to communicate with the ALS teams at the scene and during transfer. Data, including clinical and diagnosis data, vital signs, and management data were collected in case medical record forms.

We divided the efficacy of telegraphic medicine into four categories according to the principle guidelines for treatment of emergency patients:

First was the ability to make a primary diagnosis, which had to be consistent with the definite diagnosis of the final doctor or specialist.

Second was proper airway management including oxygen therapy and type of administration, as well as essential medication such as bronchodilators, steroids, or antibiotics.

Third was proper circulatory management including intravenous fluid resuscitation and intravenous medication.

Fourth was neurological treatment including management of stroke and seizure cases including activation of the fast-track team, administration of drugs to lower intracranial pressure or relieve symptoms, Glasgow coma scale evaluation, and stabilization of the spine.

2. Experienced emergency physicians were defined as certified board emergency medicine physicians with two years experience working in the emergency room and not involved in the statistical analysis of the present study. Medical records and nurses' notes were given to them for evaluation. The names of patients and doctors in charge were hidden. Experienced emergency physicians gave scores ranging from 0 to 100 depending on the treatment that was conducted according to the nurses' notes. Scores of more than 80 with no major faults were defined as appropriate management. The references of standard management were the clinical practice guidelines for each condition.

3. An emergency medical dispatcher (EMD) dispatched an ALS team when the phone triage level of the patient was "Red". Red patients included those

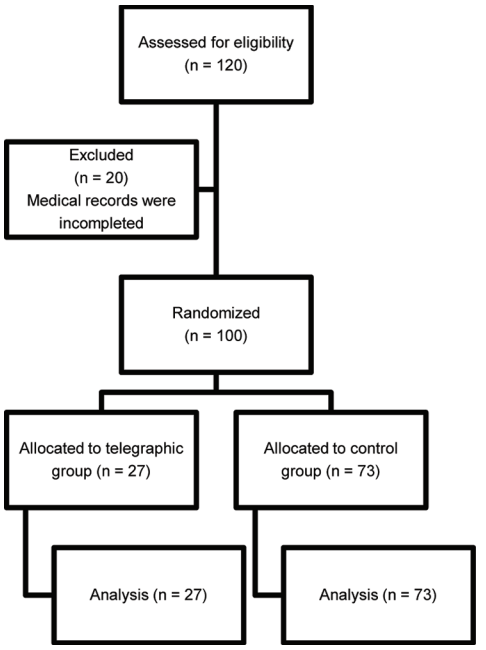

Fig. 1 Consort diagram.

suffering from apnea, severe respiratory distress, hypoxemia, acute mental status change, severe pain, multiple injuries, and those who are unresponsive.

Statistical analysis

Continuous data were presented as a percentage. Chi-square was used to determine significant difference between the test group and the control group. A $p<0.05$ showed statistical significance.

Results

There were 120 pre-hospital emergency ALS responses during the study period. After reviewing the inclusion and exclusion criteria, 100 patients were enrolled in the present study. Twenty-seven patients were randomized into the intervention group. Sixty-three percent of participants were male. The highest rate of ALS responses occurred during the morning shift and the lowest rate was during the night shift. Ninety-four percent of patients contacted EMS using the public telephone number 1669. Of these calls, 86% were made by people who were not medical professionals. The majority of cases were non-traumatic cases (Table 2). There were 46 responses in which physicians were present with the ALS team (Table 1).

In the telegraphic group, primary diagnoses were made in 74% of cases compared with 26% in the control group ($p<0.01$). However, rate of appropriateness in airway management, circulatory management and neurological management were not statistically significant (Table 3).

For the subgroup of ALS teams without physician accompaniment, the difference in the rates of primary diagnosis between teams that used

Table 1. Basic characteristics of participants

Characteristics	Telegraphic group n (%)	Control group n (%)	*p*-value
Male	16 (59.3)	47 (64.4)	0.64
Age (mean ± SD)	51.00±8.66	59.00±5.36	
Time of onset			
8 a.m. to 4 p.m.	16 (59.3)	31 (42.5)	
4 p.m. to 12 a.m.	10 (37.0)	31 (42.5)	
12 a.m. to 8 a.m.	1 (3.7)	11 (15.0)	
Access to EMS			
Public telephone No. 1669	26 (96.3)	68 (93.2)	
Radio signal	0	4 (5.5)	
Others	1 (3.7)	1 (1.3)	
First contact with EMS			
By standers	21 (77.8)	65 (89.0)	
Healthcare workers	3 (11.1)	5 (6.8)	
Others	3 (11.1)	3 (4.2)	
Physician accompaniment	9 (33.3)	37 (50.7)	0.12
Trauma	5 (18.5)	16 (21.9)	0.71
Total	27 (100)	73 (100)	

EMS = emergency medical service

Table 2. Final diagnosis of non-traumatic cases

System	Diagnosis	n
Airway	Acute asthmatic attack and chronic obstructive pulmonary disease	9
	Secretion obstruction	3
	Pneumonia	5
	Hyperventilation	4
Circulation	Sepsis/septic shock	10
	Acute coronary syndrome	3
	Hypertensive crisis	4
	Heart failure	4
	Aortic aneurysm	1
	Acute diarrhea with dehydration	5
Neurology	Stroke	6
	Hypoglycemia with alteration of consciousness	4
	Seizure	3
	Toxin ingestion with alteration of consciousness	2
	Central nervous system infection	3
	Alcohol intoxication	3
Others	Advanced cancer	3
	Other diseases	7
Total		79

telegraphic systems and teams without telegraphic systems was statistically significant at 94.4% vs. 2.8% (p<0.01). The percentage of cases in which appropriate airway management, circulatory management and neurological management were carried out also increased in the group that used telegraphic systems (Table 4).

In the subgroup of ALS teams with physician accompaniment, the rate of making primary diagnoses and rates of appropriate airway, circulatory, and neurological management were comparable regardless of telegraphic system usage (Table 5).

Discussion

In the Thai EMS system, the majorities of healthcare providers are emergency medical responders, emergency medical technicians, or advanced emergency medical technicians. Physicians are in short supply and mainly provide services in the emergency room. For this reason, we still have a high-risk of preventable death during the transferring of patients from the scene of the emergency to the hospital. Telegraphic medicine, a type of telemedicine or tele-health system, is a promising tool to solve this problem.

Telemedicine has been shown to improve EMS systems in deficiency conditions, including deficiencies in human resources, transportation[5,6], and time[3], in many countries. Previous studies have demonstrated that airway[7], circulatory[8,9], and neurological[10] management are improved when the ALS teams without physician accompanied use telemedicine. Telemedicine has been widely studied in cases of stroke and acute coronary syndrome, in which timely diagnosis and management are required[11,12].

The present study found that telegraphic medicine systems significantly increased the percentage of primary diagnoses. It also increased the percentage of appropriate airway, circulatory, and neurological management but not statistically significant.

We conducted subgroup analysis in the ALS teams without physician accompaniment. The results showed that telegraphic medicine systems significantly augmented primary diagnosis and appropriate airway, circulatory, and neurological management. Telegraphic medicine systems transferred real-time data to physicians who were able to guide the nurses and medical technicians at pre-hospital scenes for diagnosis and treatment. Telegraphic medicine systems could potentially compensate for the lack of accompanied physician in times of shortage of emergency physicians. However, in the ALS teams with physician accompaniment, the telegraphic medicine systems did not increase the rates of appropriate diagnosis or management in any of the above categories.

In adopting telegraphic medicine systems as routinely used tools, there are a few issues that should be considered. The first is cost effectiveness. Agha et al found that cost effectiveness of telemedicine was related to an adequate volume of patients and the sharing of the systems with other users[13]. This might imply that a larger hospital with a larger budget should initiate the systems and share them with other hospitals on the network. Consideration of the criteria to determine whether the systems used are also vital. Strong evidence had shown that these systems are effective in the treatment of cardiovascular disease[11,12]. In the present study, telegraphic medicine systems improved outcomes in cases of ALS teams were not

Table 3. Appropriateness of medical management between the telegraphic group and control group

Management	Telegraphic group n (%)	Control group n (%)	p-value
Primary diagnosis	20 (74)	19 (26)	<0.01
Airway management	14 (52)	27 (37)	0.18
Circulation management	14 (52)	26 (36)	0.14
Neurological management	14 (52)	27 (37)	0.18

Table 4. Appropriateness of medical management in ALS teams without a physician compared between the telegraphic group and control group

Management	Telegraphic group (n = 18)	Control group (n = 36)	p-value
Primary diagnosis	17 (94.4%)	1 (2.8%)	<0.01
Airway management	11 (61.1%)	8 (22.2%)	<0.01
Circulatory management	11 (61.1%)	9 (25.0%)	<0.01
Neurological management	10 (55.5%)	8 (22.2%)	0.014

Table 5. Appropriateness of medical management in ALS teams with a physician compared between the telegraphic group and control group

Management	Telegraphic group (n = 9)	Control group (n = 37)	p-value
Primary diagnosis	3 (33.3%)	18 (48.6%)	0.4
Airway management	3 (33.3%)	19 (51.4%)	0.33
Circulatory management	3 (33.3%)	18 (48.6%)	0.4
Neurological management	4 (44.4%)	20 (54.0%)	0.6

accompanied by a physician. However, no benefits were shown if there were physician accompaniment. It is important that specific committees of hospital experts outline institutional usage criteria of telegraphic systems. In addition, there are matters of privacy and data security. All data must be kept in highly secure. There should be a limited number of users, each registered with a username and password, who can access the data.

According to the Ministry of Public Health, there are several medical fast tracks including acute coronary syndrome, stroke, sepsis, trauma, and neonatal fast tracks. Each of these requires quality medical care at the pre-hospital scene until admission[3,12]. Telegraphic medicine is a promising strategy to improve pre-hospital EMS in the future. However, further study of its efficacy and cost effectiveness using larger numbers of participants is required.

Conclusion

Non-physician responders mainly provide pre-hospital services or EMS in Thailand. Telegraphic medicine was shown to improve pre-hospital care in ALS teams without a physician in four categories including diagnosis, airway management, circulatory management, and neurological management. Thus, it is a promising system to use in EMS in Thailand, and further study is recommended.

What is already known on this topic?

In western and developed countries, telemedicine has proved useful in many situations including lack of emergency physicians, poor transportation, and pre-hospital fast tracks such as ACS or stroke. Telemedicine provides essential information from patients to distant healthcare providers such as vital signs, EKG, and real-time video and audio. Thus, in situations without a physician at the scene, decisions can be made in a timely manner and improve patients' prognoses.

What this study adds?

This study was the first to prove that telemedicine or telegraphic systems were effective in EMS systems in Thailand and should be studied further in other developing countries or rural areas.

Acknowledgement

We are thankful to the emergency medicine department at Maharat Nakhon Ratchasima Hospital for supporting us with equipment and staffs during the study period.

Potential conflicts of interest

None.

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ระบบโทรเวชกรรมร่วมกับชุดปฏิบัติการการแพทย์ฉุกเฉินระดับสูง: การศึกษานำร่องในโรงพยาบาลระดับตติยภูมิ

สุนทร ชินประสาทศักดิ์, ศุภฤกษ์ สัทธาพงศ์, แพรว โคตรุฉิน, คุณากร มาพร

ภูมิหลัง: *บุคลากรหลักที่ออกให้บริการในระบบบริการการแพทย์ฉุกเฉินช่วงก่อนมาถึงโรงพยาบาลโดยส่วนใหญ่ไม่ใช่แพทย์เนื่องจากยังมีปริมาณของแพทย์เวชศาสตร์ฉุกเฉินไม่เพียงพอกับความต้องการ ความเสี่ยงของการเสียชีวิตของผู้ป่วยจากสาเหตุที่แก้ไขได้ระหว่างการให้การรักษาและระหว่างการส่งต่อยังคงมีอัตราสูง ระบบโทรเวชกรรมเป็นความหวังหนึ่งในการแก้ปัญหานี้*

วัตถุประสงค์: *เพื่อศึกษาถึงประสิทธิผลของระบบโทรเวชกรรมเมื่อนำมาใช้ร่วมกับบุคลากรชุดปฏิบัติการการแพทย์ฉุกเฉินระดับสูง*

วัสดุและวิธีการ: *การศึกษานี้เป็นการศึกษานำร่องในโรงพยาบาลระดับตติยภูมิโดยใช้ระบบโทรเวชกรรม ได้แก่ การส่งสัญญาณภาพเสียง คลื่นไฟฟ้าหัวใจ และสัญญาณชีพจากระยะไกล ณ จุดเกิดเหตุและบนรถพยาบาลมายังห้องที่มีจอแสดงผลในโรงพยาบาลโดยใช้ควบคู่กับบุคลากรชุดปฏิบัติการการแพทย์ฉุกเฉินระดับสูง โดยวัดประสิทธิผลของระบบโทรเวชกรรม 4 ด้าน ได้แก่ ความสามารถในการช่วยวินิจฉัยเบื้องต้น การดูแลระบบทางเดินหายใจอย่างเหมาะสม การดูแลระบบไหลเวียนโลหิตอย่างเหมาะสม และการดูแลระบบประสาทอย่างเหมาะสม ซึ่งแต่ละด้านจะประเมินโดยแพทย์เวชศาสตร์ฉุกเฉินที่มีประสบการณ์สูง*

ผลการศึกษา: *ผู้ป่วยที่ทำการรักษาก่อนถึงโรงพยาบาลในการศึกษานี้มีจำนวน 100 ราย ผู้ป่วย 27 ราย ถูกสุ่มเข้าสู่กลุ่มทดลองที่มีการใช้ระบบโทรเวชกรรม การใช้ระบบโทรเวชกรรมร่วมกับทีมบุคลากรชุดปฏิบัติการการแพทย์ฉุกเฉินระดับสูงที่ไม่มีแพทย์ออกเหตุร่วม ทำให้ได้การวินิจฉัยเบื้องต้นมากถึงร้อยละ 93 ในขณะที่กลุ่มควบคุมวินิจฉัยได้เพียงร้อยละ 4 เท่านั้น ($p<0.05$) ความเหมาะสมในการดูแลระบบทางเดินหายใจในกลุ่มที่ใช้ระบบโทรเวชกรรมคิดเป็นร้อยละ 63 ในขณะที่กลุ่มควบคุมได้ร้อยละ 22 ($p<0.01$) ผลการศึกษาเป็นไปในแนวทางเดียวกันในด้านความเหมาะสมของการดูแลระบบไหลเวียนโลหิตและระบบประสาท*

สรุป: *ระบบโทรเวชกรรมได้รับการพิสูจน์แล้วว่าสามารถเพิ่มศักยภาพในการดูแลรักษาผู้ป่วยก่อนมาถึงโรงพยาบาลเมื่อใช้ร่วมกับบุคลากรชุดปฏิบัติการการแพทย์ฉุกเฉินระดับสูงที่ไม่มีแพทย์ออกเหตุร่วม โดยมีประสิทธิผลทั้ง 4 ด้าน ได้แก่ การวินิจฉัย การดูแลทางเดินหายใจ ระบบไหลเวียนโลหิต และระบบประสาท ดังนั้นระบบโทรเวชกรรมจึงเป็นความหวังของระบบบริการการแพทย์ฉุกเฉินของประเทศไทย*
