Emergency critical care service in emergency medicine ward: the experience in North Lantau Hospital

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With the increased demand of critical care, emergency physicians often provide a significant proportion of critical care for the critically ill patients apart from their primary roles in resuscitation and initial stabilisation. The dual training pathway of emergency medicine and intensive care medicine enables the Accident and Emergency Departments (AEDs) to be staffed with emergency intensivists to provide care of critically ill patients in the AEDs beyond the initial resuscitation. North Lantau Hospital is a community hospital located in central Tung Chung of Lantau Island. Transporting critically ill patients to the nearest tertiary hospital requires a significant amount of time which poses high risk to them. An "Emergency Critical Care Management" pilot program was created under these circumstances. In this pilot program, up to 2 beds in the Emergency Medicine Ward (EMW) are used for managing critically ill patients. The experience and preliminary outcomes of implementing critical care service in the EMW are shared in this article. (Hong Kong j.emerg.med. 2017;24:25-34)

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Introduction

The demand for critical care services is increasing owing to the population aging, rapid population growth, high prevalence of chronic medical diseases, increasing technological demand and increased expectation of health care service from the public. Critical care is defined as the delivery of medical care to "any patient who is physiologically unstable, requiring constant and minute-to-minute titration of therapy according to the evolution of the disease process". Critical care is defined physiologically rather than geographically and thus, the definition of critical care could extend to any location outside the Intensive Care Unit (ICU). In fact management of critically ill patients is also one of the most fundamental and essential roles of the Accident and Emergency Department (AED) in the health care system. Emergency physicians are often responsible for providing resuscitation and critical care for patients in their early phase of critical illnesses.

The dual-fellowship training pathway of emergency medicine (EM) (Fellowship of Hong Kong College of Emergency Medicine) and intensive care medicine (ICM) (Fellowship of Hong Kong College of Anaesthetists [Intensive Care]) has been established to facilitate and formalise the qualified training of EM/ICM in Hong Kong. This dual-fellowship training not only strengthens critical care delivery in the AED but also facilitates the coordination of the management of critically ill patients at the AED-ICU interface. By the end of 2016, there are 4

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North Lantau Hospital (NLTH) is a community hospital located in central Tung Chung of Lantau Island, which provides a 24-hour accident and emergency service, and various outpatient services serving the population of the Lantau Island and also the floating population in the Hong Kong International Airport at Chek Lap Kok. The AED of NLTH began services on 24th September 2013 and the Emergency Medicine Ward (EMW) began its service on 24th September 2014. The EMW of NLTH consists of 20 beds and shares the same ward with the Extended Care (EC) beds of the Medicine and Geriatrics Department of NLTH. The EMW serves all the acute in-patient service of the NLTH while the EC beds mainly provide care for the convalescent patients from Princess Margaret Hospital (PMH).

With the rapid development of Tung Chung and increasing population, the health service need in the district is also increasing. Increasing number of complicated critical cases is encountered together with the increase in the number of patients attending the AED. As there is no acute medical ward and ICU services in NLTH, the responsibility of resuscitation and initial stabilisation of critically ill patients entirely falls to the emergency physicians. After initial stabilisation, critically ill patients are transported to the nearest tertiary hospital, PMH. The transport time is about 40 minutes and is sometime prolonged when there is incident occurring in the highway. The long transport time always poses high risk to the critically ill patients and also a great challenge to the doctors and the nursing staff.

An "Emergency Critical Care Management" pilot program was created in response to this challenge, with the objectives of extending the spectrum of patient care in the EMW, enhancing utilisation of existing resource in NLTH, minimising risk of patient transport, and ultimately improving the quality of patient care. In the EMW of NLTH, up to 2 beds are used for managing critically ill patients. The patients are under the care by the EMW team, which includes EM specialists with specialised training in intensive care and the EMW nursing staff who are further supervised by an emergency intensivist.

The target groups of critically ill patients include:
1. Severe sepsis or septic shock
2. Respiratory failure (chronic obstructive airway disease [COAD] exacerbation and acute pulmonary oedema [APO]) requiring non-invasive ventilation (NIV) support
3. Diabetic emergencies (diabetic ketoacidosis [DKA] and hyperosmolar hyperglycemic state [HHS])
4. Hypertensive urgency
5. Severe electrolytes disturbance (hypokalaemia and hyper/hyponatraemia)
6. Critical toxicology conditions
7. Environmental emergencies, e.g. hypothermia, heat exhaustion/stroke
8. End-of-life care

Extended resuscitation can also be provided for critically ill patients whose conditions only need a short period of intensive care. In these circumstances, the EMW serves as a step down unit to minimise the risk of long distant transport and also relieve the workload of PMH. These patients are directly transferred to the EC beds for convalescent care and rehabilitation after their acute phase of critical illnesses.

The capabilities of the EMW beds for the emergency critical care management pilot program are delineated in Table 1. For the quality assurance and risk management, training programs have been provided to both emergency physicians and nurses including teaching programs (from emergency intensivist and ICU nursing consultant) about the NIV, mechanical ventilation, central venous catheterisation (CVC) care and basic ICU care. Regular clinical attachment to ICU has been arranged for the emergency physicians who are responsible for managing critically ill patients in the EMW. There are regular resuscitation training and case review/mortality and morbidity meetings for cases sharing. Standardised guidelines for sepsis management, NIV care, mechanical ventilation care and CVC care have also been set up.
Our experience and cases sharing

Until the end of November 2016, we have managed 145 cases in the EMW including 22 NIV cases and 27 cases for end-of-life care.

Management of patients with infectious diseases, severe sepsis and septic shock

Emergency physicians take up the primary role in the care of critically ill septic patients. Early aggressive management of sepsis (early antibiotic therapy and haemodynamic support) in the AED has been shown to improve patient’s survival. The emergency intensivist could provide additional opinion on the antibiotic choices, aggressive source control and advanced haemodynamic monitoring to optimise the care of critically ill septic patients. More than half of the critically ill patients requiring care in the EMW under our emergency critical care management program were due to sepsis (with organ dysfunction, bacteremia or septic shock). More than 90% of the patients could be successfully managed in our EMW. Six cases were eventually transferred to PMH for further management including 2 cases of Klebsiella bacteremia with septic shock and multi-organ dysfunction (for ICU care), 1 case of Methicillin-resistant Staphylococcus aureus (MRSA) bacteremia (for echocardiogram assessment by cardiologist), 1 case of Salmonella gastroenteritis complicated by acalculous cholecystitis (for surgical intervention), 1 case of pelvic inflammatory disease with Escherichia coli septicemia (for gynaecological assessment), and 1 case of emphysematous cystitis with acute retention of urine (for urological intervention). Two elderly patients with multiple comorbidities died of MRSA pneumonia with bacteremia and Klebsiella empyema with bacteremia respectively. Some interesting cases are reported including critical infection conditions and also rare infectious diseases.

Case 1

A 46-year-old man with history of diabetes mellitus (DM) presented to the AED with high fever. He did not have chest, gastrointestinal tract or urinary symptoms. On arrival to the AED, he was in critical condition with hypotension, heart rate (HR) of about 150 bpm and body temperature (Temp) of 40°C. His condition was stabilised with intravenous (IV) fluid resuscitation. Septic workup was done and empirical antibiotic therapy was started in the AED. After the initial stabilisation, the patient was admitted to the EMW for further management. His liver function was found to be mildly deranged (alkaline phosphatase 231U/L [reference range 30-120]) and his blood culture grew *Klebsiella pneumonia*. Bedside ultrasound (USG) showed hypoechoic lesions at segment VII which was confirmed to be liver abscesses by the computed tomography (CT) scan (Figure 1). The liver abscesses were managed with medical treatment as their sizes were small and the patient improved with antibiotic therapy. The ophthalmologist assessed the patient and there was no evidence of endophthalmitis due to the *Klebsiella* infection. The patient was eventually discharged from the EMW and was prescribed with 6-week course of antibiotic. His follow-up CT scan showed resolving liver abscesses.

Case 2

A 69-year-old man, who had history of DM, hypertension (HT), hyperlipidaemia, multiple myeloma and newly diagnosed carcinoma of stomach,
presented to the AED with fever and non-productive cough. On arrival to the AED, his blood pressure (BP) was 138/72 with HR, respiratory rate (RR) 30 per minute, Temp 39.6°C and SpO₂ (pulse oximeter oxygen saturation) on 98% on room air. His chest X-ray (CXR) showed haziness at the left perihilar region (Figure 2). Laboratory results showed normal white cell count, creatinine level 159 umol/L (reference range 64-104), sodium level 127 mmol/L (reference range 136-146) and normal liver function. The patient was admitted to the EMW and treated as community-acquired pneumonia. However, he developed respiratory failure and shock on the next day of admission. Repeated CXR showed bilateral lung infiltrates (Figure 2). Urine *legionella* antigen test done on admission was found to be positive. The patient eventually recovered with a course of doxycycline and levofloxacin together with supportive therapy in the EMW.

**Case 3**

A 85-year-old man with history of chronic renal impairment, atrial fibrillation and schizophrenia was admitted to the EMW for management of pneumonia with septic shock. His condition improved with antibiotic therapy and he eventually weaned off vasopressor support. However, he developed persistent fever and his CXR showed persistent right lower lobe haziness. Bedside USG showed right pleural effusion with multiple septae (Figure 3). Pleural catheter was inserted at bedside under USG guidance but only insignificant amount of pleural effusion was drained. CT scan of thorax showed loculated right pleural effusion. Intra-pleural fibrinolysis was then performed. The patient recovered after the treatment and was eventually discharged home.

**Case 4**

A 57-year-old lady with history of DM and hyperlipidaemia was admitted to the EMW for high fever with a skin lesion at her forehead (Figure 4). Her Temp was up to 41°C on arrival to the AED. Her other vital signs were stable. Laboratory results showed thrombocytopenia with platelet count of 61x10⁹/L (reference range 145-370x10⁹), deranged liver function and elevated troponin level (0.06 ug/L; reference range <0.04 ug/L). Her electrocardiogram (ECG) showed no ischaemic change. A provisional diagnosis of scrub
typhus was made and the patient was treated with doxycycline empirically. The *Rickettsia* serology tests later confirmed the diagnosis of scrub typhus. The patient eventually recovered with the antibiotic therapy and discharged from the EMW.

The essentials for successful management of patients with sepsis include early recognition, prompt antibiotic therapy and source control, haemodynamic support, echocardiogram skills for haemodynamic and fluid responsiveness, experience in management of infectious diseases and collaborations with other specialists including microbiologist, radiologist and surgeon.

**Management of patients with respiratory failure**

Implementation of NIV in AED has been shown to be feasible and able to improve outcome of patients with COAD. A total of 22 patients requiring NIV have been managed in the EMW. Majority of patients required NIV due to COAD exacerbation with type 2 respiratory failure, including patients in critical condition when attending the AED. A 67-year-old man presented to the AED for COAD exacerbation complicated with fast atrial fibrillation. He had unstable haemodynamic state and cardioversion was performed. He was put on NIV support after admitted to the EMW. His condition improved with treatment and eventually discharged. Most of patients successfully weaned off the NIV support in the EMW and were discharged home directly or after rehabilitation in the EC beds. Only 2 patients failed NIV and required intubation. Both of them were transferred to PMH for further management. Apart from COAD exacerbation, patients with APO with respiratory failure have also been managed in the EMW. One elderly lady was admitted to the EMW for non-ST elevation myocardial infarction (NSTEMI) complicated by APO. She required NIV support and was successfully managed in the EMW. She was eventually discharged after the assessment by the medical team.

**Providing extended resuscitation and minimising risk of transport**

Implementation of critical care service facilitates extended resuscitation to be provided to those critically ill patients who have unstable condition and are at high risk.
risk of deterioration during transport. The risk of long distant transport (in the geographic situation of NLTH) could therefore be minimised. A 74-year-old female tourist from Australia developed cardiac arrest in the airport and was brought to the AED of NLTH. She had return of spontaneous circulation after cardiopulmonary resuscitation but she was in persistent shock. Bedside echocardiogram revealed a markedly dilated right ventricle. CT scan showed massive pulmonary embolism (Figure 5). She was managed in the EMW with mechanical ventilation and inotropic support. Her condition improved after intravenous thrombolytic therapy. She eventually had good neurological recovery and discharged from the EMW. She was finally safely returned to Australia. Another 79-year-old man with history of HT, DM and acute myocardial infarction with percutaneous coronary intervention done was brought from the airport for APO (Figure 6). He required intubation and mechanical ventilation. His condition rapidly improved with diuretic and nitrate therapy. Double antiplatelet therapy and low molecular weight heparin were given for his acute coronary syndrome precipitating this episode of APO. He was extubated on day 2 of EMW stay and weaned off NIV on day 3. He was discharged after the assessment by the medical team. The EMW bed serving for critical care also acts as a release valve when the ICU bed is not immediately available. It is an integrated part of the care for the critically ill patients before ICU admission. An elderly lady was brought to the AED for suicidal attempt by ingestion of insecticide at midnight. She developed respiratory failure requiring mechanical ventilation. Plasma cholinesterase activity was found to be very low. She was admitted to the EMW for initial stabilisation and management before the ICU bed is available. Atropine and pralidoxime were given for the treatment of organophosphate poisoning. Her condition was stabilised with the antidotes and inotropic support. She was transferred to PMH ICU for further

Figure 5. Computed tomography scan of thorax of a patient with massive pulmonary embolism. There was filling defect at the left pulmonary artery (Left). The right ventricle was markedly dilated (Right).

Figure 4. Clinical photos of a patient suffering from scrub typhus. There was an eschar over the patient’s forehead and generalised maculopapular rash over the body.
management on the next day. Chemical analysis of her urine confirmed the exposure of malathion. She eventually recovered and was discharged from PMH.

**Acting as step down beds**

Some of the critically ill patients after stabilisation for a short period of intensive care would become suitable to be managed in step-down beds outside the ICU. Examples of these groups of critically ill patients include patients with diabetic ketoacidosis, severe electrolytes disturbance and some critical toxicology conditions. Most cases of diabetes emergencies including DKA and HHS were successfully managed in the EMW. Two cases of "DKA" were eventually transferred to ICU for management. One patients presented with hyperglycaemia and metabolic acidosis but was subsequently diagnosed with acute pancreatitis. Another patient was transferred to ICU for management of Klebsiella bacteraemia complicated with DKA. All uncomplicated DKA cases were able to be stabilised within the first day of EMW stay. Complications from these diabetic emergencies have also been encountered. A 36-year-old lady with schizophrenia was admitted to the emergency critical care bed for management of HHS with spot blood glucose of 88 mmol/L on admission. Her metabolic disturbance was normalised after intravenous fluid replacement and insulin therapy. However, she developed left lower deep vein thrombosis and pulmonary embolism on day 5 of EMW stay. She recovered with the anti-coagulation therapy and was eventually discharged from the EMW.

**Providing expert management for critical toxicology patients**

Clinical toxicology fellowship has been established as the first subspecialty under the Hong Kong College of Emergency Medicine. Implementation of critical care service in the AED provides opportunity for the emergency physicians to obtain experience in managing patients with critical toxicology conditions. Two patients with digoxin overdose requiring DigFab® treatment have been successfully managed in our EMW.

**Special procedures**

Emergency intensivists are trained for various critical care procedures such as CVC and bronchoscopy. An

![Figure 6. Chest radiography (CXR) of a patient with acute pulmonary oedema requiring intubation and mechanical ventilation. CXR taken in accident and emergency department showed congested lung fields (Left). The lung fields cleared up after treatment (Right).](image-url)
elderly lady with Alzheimer’s disease presented to the AED with respiratory failure due to aspiration of congee (Figure 7). Bedside bronchoscopy with bronchial toileting was performed in the resuscitation room. Large amount of congee was extracted from the right lower bronchi. Her condition was stabilised after the procedure and she was then admitted to the EMW for further management. She recovered after a course of antibiotic therapy and chest physiotherapy. Specialised procedure could also be performed in the EMW under close monitoring. A 69-year-old lady with history of bronchiectasis and allergy to cephalosporin was admitted to the EMW for Pseudomonas pneumonia. The Pseudomonas strain in her sputum culture was resistant to quinolones. Antibiotic desensitisation with ceftazidime was performed in EMW under close monitoring with invasive blood pressure monitoring. The procedure was uneventful and she recovered after a course of ceftazidime treatment.

End-of-life care

A “Comfort Care in the Last Journey” program has been started in the EMW to provide end-of-life care for patients with terminal malignancy or other terminal illnesses with documented advanced directives, post-cardiac arrest patients with profound hypoxic brain injury, and patients who suffer from advanced, progressive and irreversible diseases failed to respond to optimal therapy. The aims of this program are to promote dying with dignity, treasure the terminal phase of life and relieve the stress of the patient’s relatives. Individualised cares are provided including adequate analgesic and sedative to relieve the distressing symptoms, private area, flexible visiting hour for patient’s families, pastoral care, religious support, financial and social support from medical social worker if needed.

Discussion

Emergency Department Intensive Care Units (EDICUs) have been established in the AEDs of the United State (US) for many years to provide aggressive critical care for critically ill patients in the AEDs. There are 2 models of practice in the US: the resource intensivist model and the hybrid EDICU model. In the resource intensivist model, the emergency intensivist fulfills a standard clinical role in the AED and also provides his/her expert care for the critically ill patients in the AED. In this model, the emergency intensivist has similar role of the clinical toxicologist in the AED who improves the care of poisoned patients. The emergency intensivist also bridges the gap between the AED and ICU by facilitating consistent care for
critical illnesses before the critically ill patients are admitted to the ICU. In the hybrid EDICU model, there is a dedicated area in the AED for managing critically ill patients. This hybrid area (EDICU) is staffed by emergency intensivist, dedicated AED doctors and nurses. The primary goal of an EDICU is to create an area in the AED capable of providing the baseline care of an ICU. Specific training is provided for the dedicated doctors and nurses. Standardised protocols and care pathways are created so that the AED doctors could provide a more advanced intensive care for the critically ill patients even when the emergency intensivist is not on shift. In our nearby countries including mainland China, Taiwan, Singapore, Japan and Macau, the emergency physicians have to manage critically ill patients in their own clinical areas and some of them have already been running their own EDICUs. In fact our fellowship training in EM has provided a strong foundation for the post-fellowship training in ICM for the EM specialist and also the development of more advanced critical care in the AED in the future.

Advantages of implementing critical care in the AED
Critically ill patients require critical care from arrival to the AED but the care of the critically ill patients before admission to the ICU is often suboptimal. Providing high quality of care for the critically ill patients early in the AED has been shown to improve their subsequent mortality and morbidity. Early intensive care could also lead to a reduction of the length of hospital stay resulting in a significant cost saving. The long transport time not only poses a significant risk to the critically ill patients but also requires a significant amount of manpower resources. Providing critical care for critically ill patients in the AED could minimise the risk of long distant transport and enhance the allocation of the health care resources. It also could provide a more in-depth exposure of critical care and enhance the knowledge about management of critically ill patients for the emergency physicians. This may also encourage the new graduates to enroll in the EM specialty training. The critical care service enables the AED to manage more complicated toxicology cases and it in turn could facilitate the further development and training of clinical toxicology in our specialty. Similarly, the development of critical care also enhances the knowledge and experience of emergency physicians in managing different infectious diseases. Furthermore, development of critical care in the AED allows exploring a new research area for EM.

Challenges
Emergency physicians are trained to manage the entire spectrum of diseases, from minor injuries to critical illnesses. EM training mainly focuses on the detection and resuscitation of critically ill patients. However, local emergency physicians are lack of training on the long-term perspective of the management of critically ill patients, including weaning from mechanical ventilation, nutrition and other more chronic aspects of ICU management. Similar to the training of emergency physicians, the concept of "routine critical care nursing" is also not part of an emergency nurse's knowledge base. Further training for managing critically ill patients is essential for both the AED doctors and nurses for the development of critical care in the AED. Under the current training pathway, it takes another 3 years for an EM specialist to obtain the second fellowship in ICM. It needs additional manpower resources for the emergency physicians to be qualified as an emergency intensivist. With the consideration of sustainability of the critical care service, sequential plan for the training of critical care for the AED doctors in NLTH is proceeding. Another EM specialist in NLTH is now engaged in the fellowship training of ICM.

Future development: an enhanced model of EMW service
The EMW serves the primary roles of reducing avoidable admissions and improving the quality of short-stay patient care. It is also designed to be a suitable platform for multi-disciplinary and cross-specialty collaboration in managing selected acute conditions. In order to meet the unique service needs in different hospitals, like the situation in NLTH, the services of EMW have to be enhanced to provide an emergency physician-led integrated care for a broader spectrum of patient care, such as, emergency critical care beds, end-of-life care, post-operative care for elective surgery patients and integrated care for acute...
medical patients by collaboration with medical specialists. This enhanced model of EMW service could improve the quality of patient care, minimise the risk of patient transport, enhance the utilisation of existing resources in the hospital, reduce the workload of the tertiary hospital, enhance the exposure of AED doctors for a broader spectrum of diseases and improve their training.

Conclusions

The experience of our "Emergency Critical Care Management" pilot program in the EMW of NLTH demonstrates that it is feasible to provide critical care service in the AED and most of critically ill patients recovered after the critical care provided in the AED and EMW. Providing critical care in the AED not only can be life-saving, but also can benefit the resources allocation and utilisation in hospitals with limited ICU care or without ICU. However, this is only the first step of the development of critical care in our EM specialty. Apart from the training for the emergency physicians, the development of "emergency critical care nursing" is the other key to success.

References