Telemedicine in the ICU, a review

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Abstract - Telemedicine is medicine practiced from a distance. In the United States tele-ICU, a form of telemedicine has been instituted as a solution for the shortage of intensivists. Intensivists provide daily ICU care from a distance. Tele-ICU seems most effective for rural and/or small ICUs that do not have round-the-clock intensivist staffing. In this situation, the implementation of tele-ICU can lead to a decrease in Length Of Stay and ICU mortality. Another benefit of tele-ICU is enhanced adherence to guidelines. Telemedicine in the Netherlands is currently only used in the form of teleconsulting.

Keywords - telemedicine, teleconsulting, intensivist shortage, tele-ICU

Definitions and history
Telemedicine is medicine practiced from a distance using telecommunication. In 1972 a telemedicine project was set up between the Intensive Care Unit (ICU) of a large university hospital and a small inner-city hospital in the United States, consisting of a two-way audiovisual link and mobile camera [1,2]. A daily consultation was performed by an intensivist from the remote hospital. Hospital mortality decreased during the project but the contribution of telemedicine could not be assessed [1]. Due to large financial problems of the inner-city hospital, the project was closed down and telemedicine in the ICU environment seemed to be forgotten for a long period.

Intensivist staffing and telemedicine
In the last fifteen years, telemedicine has regained popularity in the light of several studies showing that 24/7 intensivist staffing leads to a reduction of ICU and hospital mortality and Length of Stay (LOS) compared to a non-intensivist ICU model [3,4]. Additionally, the 24/7 staffing of intensivists is not only safer for patients but also cheaper for the hospital [3,4].

As a result of these studies, the Leapfrog group, an advisory board attempting to improve the quality of US hospital care, has written a guideline for ICUs [5]. According to this guideline, a board certified intensivist should maintain 24/7 care of the ICU patient, respond to a call within 5 minutes and an FCCS certified physician who has a response time of < 5 minutes should always be present in the ICU [5-7]. Before the implementation of the Leapfrog standard, 4% of ICUs met these Leapfrog criteria. Three years after publication of the guideline, intensivist staffing according to this model was 23%, and in 2009 37% of ICUs met these criteria [5,6,8,9]. Due to a lack of intensivists in the USA, a higher rate of 24/7 intensivist staffing is difficult to accomplish, especially in rural areas. Moreover, due to the increased elderly population in the United States, a shortage of 22% of intensivists is predicted for 2020, and 30% for 2030 [8]. This current shortage of intensivists – which will get worse in the near future - calls for a more efficient use of intensivists.

In 1997 Rosenfeld performed a before and after study on the implementation of a tele-ICU in a surgical ICU. The results were comparable with implementation of a 24/7 intensivist staffing model [10]. Rosenfeld concluded that tele-ICU might be a solution for the intensivist shortage in the USA. In cooperation with a commercial health care company he started the VISICU company, one of the three commercial companies that sell tele-ICU systems, the others being iMD-Soft and Cerner [11]. Nowadays more than 250 remote ICU programmes have been implemented, covering approximately 10% of ICU beds in the USA.

Organization of a tele-ICU
Most programmes consist of a flagship institution, a major academic centre or a large tertiary care facility [12]. Subsequently, multiple ICUs link up to a centralized remote care centre. It is important to realize that tele-ICU does not replace bedside personnel but uses the intensivist in a more efficient way, especially for smaller and rural ICUs. In the US situation, more than 50 to 60 ICU beds have to be involved to make the remote care programme cost-effective [12,13]. The team at the remote care centre consists of an intensivist who is responsible for 60-120 patients, one or more ICU nurses and a clerical assistant. A remote care ICU nurse is responsible for 30-40 patients and one clerical assistant is necessary for 50-125 patients [12,13]. Most intensivists work as on-site intensivists in the flagship institution and work a few shifts per month in the tele-ICU [14]. The hours of operation of the remote site vary – ICU nurse coverage is usually 24/7 and intensivist coverage depends on the hours an intensivist

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is physically present in the ICU [12,13]. Each remote ICU employee occupies a workstation with several screens displaying bedside monitor data including real-time waveforms, the patient’s electronic medical record (EMR), audiovisual links and telephone lines (see figure 1) [14]. The remote team has to have access to radiology examinations, electrocardiograms and other clinical tests [12]. Audio and video equipment is installed in the patient’s room, the resolution of the video system should be high enough to zoom in to read infusion pump settings and to evaluate breathing patterns and pupil responses of patients. The video equipment is usually switched off but can be activated by the remote site team. The video system is a two-way system which allows the on-site team and the patients to see the remote team and vice versa [12].

During daytime the tasks of the remote ICU nurse, when a remote intensivist is not present are – to be available for consultation and to document for compliance with protocols or evidence-based interventions [14]. During the night time, the remote ICU nurse makes virtual rounds of every patient at regular intervals or at the request of her bedside-counterpart. In addition to her daytime tasks she will pro-actively inform the remote intensivist concerning any potential problems. The tasks of the remote intensivist are usually 1) evaluating all new admissions, 2) conducting virtual rounds, 3) responding to acute problems, 4) distant supervising of procedures performed by the on-site physician, 5) responding to so-called “smart alarms” of the system, e.g. an alarm pops up when DVT prophylaxis has not been started or urine output has been too low for a number of hours and, 6) responding to questions from the on-site team [13,14]. The remote team classifies patients in different categories of acuity, this determines the frequency of virtual rounds [13,14]. The on-site team can always contact the remote team in the case of emergencies. A management team of an intensivist and an ICU nurse is responsible for communication and agreements concerning the responsibilities of the on-site and the remote team [13], to maintain adherence to guidelines and to develop standard operating procedures [12].

Imperative factors in this form of telemedicine are good communication and clear agreements between the on-site and the remote teams. Each patient must have a comprehensive daily care plan, usually developed by the on-site team. Frequent assessment of the ICU patient is necessary, during daytime this is the responsibility of the on-site team and during off-hours this is performed by the remote team [12]. Different levels of autonomy of the remote team can be assigned by the attending physician to the remote team. This varies from allowing the remote team to only intervene in emergency situations (category 1), to allowing the remote team to provide all ICU service when no physician is present in the ICU (category 3) [12]. In order to be able to perform the task of the remote team, all members of that team need to have good clinical skills and significant experience in caring for critically ill patients. Experiments have been performed with critical care fellows in the remote team, but the on-site doctors were not willing to grant autonomy to fellows which resulted in failure of the programme [12].

Technology

Obviously, the implementation of a remote care programme requires an investment of hardware and software, the setting up of a remote care centre and the training of both teams. The financial investment usually needed is USD 45,000 to 50,000 per ICU bed, assuming the whole IT system needs to be upgraded [12,13]. The annual budget for tele-ICU is USD 28,000 to 30,000 per ICU bed [13]. Depending on how many ICUs will link in to the tele-ICU, the usual investment for the remote centre exceeds USD 2 million [12]. The technology department of the remote team can also generate daily reports on adherence to guidelines and best practice. The on-site team can then use these reports to help identify areas for improvement.

Effectiveness of tele-ICU

The first articles on tele-ICU were published by the VISICU [7;10], but possibly contained a bias due to the company’s commercial interest in the venture. However, in recent years several publications have appeared, mostly in the form of abstracts, that give a more balanced picture a of tele-ICU [7,10,13-15-20]. Most studies were designed as a before and after analysis. Publications can roughly be divided into publications concerning effectiveness in terms of ICU and hospital mortality, and LOS, tele-ICU in rural areas, adherence to guidelines and the effects of higher rates of adherence to guidelines, and publications concerning cost effectiveness.

Studies that focused on ICU and hospital mortality and LOS showed mixed results [7,17-20]. Rosenfeld conducted a 16-week before and after study of the implementation of tele-ICU in a 10-bed surgical ICU [10]. Analysis of severity adjusted hospital mortality before and after the institution of remote intensivist monitoring showed a 30% decrease in hospital mortality and a decrease in LOS in the ICU. Breslow et al. conducted a before and after analysis study of the introduction of a tele-ICU in both a surgical and a medical ICU [7]. ICU and hospital mortality decreased significantly in the medical ICU but not in the surgical ICU. ICU LOS decreased significantly in both ICUs by 16%, while overall hospital LOS was unchanged [7]. The institution of tele-ICU in the surgical ICU of one academic hospital was associated with a significant decrease in ICU mortality and LOS, although there were large differences in the number of patients included in the different groups [16]. A significantly lower severity adjusted ICU and hospital mortality and LOS were observed after the institution of telemedicine in a hospital where intensivists were not available 24/7 prior to the implementation of tele-ICU [15]. Thomas et al. did not find an overall difference in ICU and hospital mortality or LOS, although tele-ICU was associated with improved survival and shorter ICU LOS in sicker patients (SAPS score > 44) [19]. In a recent study of more than 4,000 patients in two large suburban community hospitals, a difference in ICU and hospital mortality was not found after the institution of tele-ICU. Hospital LOS was unaffected and ICU LOS increased after the institution of tele-ICU [18]. Both hospitals had a very high quality of care before the institution of tele-ICU, with a baseline mortality of 81% of predicted and virtually no ventilator-associated pneumonia
of abstracts. Shaffer et al. found a significantly reduced amount of helicoper transfers decreased by 38% [20]. Another study showed that the institution of tele-ICU enabled some critically ill children to stay in the adult intensive care of a rural hospital [17]. This possibility was highly appreciated by the parents and the nurses [17]. The study by Zawada et al. also showed a lower ICU mortality but not hospital mortality in the largest hospital involved and a significantly lower ICU and hospital LOS in all 15 hospitals in a rural area after the implementation of tele-ICU [20].

Another component of tele-ICU is checking the daily care plan of the ICU patient for adherence to guidelines by the remote intensivist. Most programmes assign the responsibility for best practice compliance to the remote team. The technicians of the tele-ICU can very easily generate daily reports on adherence to the guidelines concerning: prevention of VAP, insulin regulation, early sepsis management and lung protective ventilation [12]. All publications regarding this subject of telemedicine are in the form of abstracts. Shaffer et al. found a significantly reduced amount of cardiopulmonary resuscitations in the ICU and outcome was slightly - but not statistically significantly - improved [23]. Due to the implementation of a standard protocol for sepsis which was double checked by the remote ICU team, mortality caused by sepsis fell from 41% to 19% (p<0.001) when compared with a historical cohort [24]. The remote team can instate a smart alert if a patient meets sepsis criteria. In one study, instituting this smart alert led to a higher compliance of the early part of the surviving sepsis bundle [25]. No data on mortality and LOS were reported in this abstract. More DVT prophylaxis in the first 48 hours of admission and tighter regulation of blood glucose levels was achieved when the remote intensivist was allowed to function in a category 3 level [26].

Articles published on the financial analysis of instituting a tele-ICU are in favour of instituting a tele-ICU [7,17,20,27]. The benefits of a shorter LOS outweigh the expensive investment costs of telemedicine, which makes tele ICU cost-effective [7,17,20,28,29]. When tele-ICU avoids air transport it is very cost-effective [27,30]. These results are in contrast with a meta-analysis on the cost-effectiveness of telemedicine in general that was performed in 2002. One of the reasons why tele-medicine could be effective in an Intensive Care setting is that an ICU stay is very expensive and achieving a shorter LOS therefore makes tele-ICU easily cost-effective. Nevertheless, one must always bear in mind the local aspects of instituting a service like tele-ICU when it comes to financial benefits. Preventing expensive air transportation by instituting tele-ICU in rural areas of the USA very easily makes it cost-effective, but in highly urbanized areas of Europe this may be a different story.

**Telemedicine in Dutch ICUs**

In 2006 a guideline for the organization of ICUs in the Netherlands was published [31]. This guideline roughly follows the Leapfrog recommendations and adds that level 1 ICUs are obliged to participate in a regional health care collaboration [31]. As a result of this guideline a few hospitals have started with tele-consulting in the ICU, a different form of telemedicine [9]. In tele-consulting the remote intensivist has access to the EMR and radiology system of the remote site. ICU patients are discussed during regular, scheduled conference calls and whenever necessary. Tele-ICU as practiced in the US has not been used so far in the Netherlands. In the Dutch situation, tele-ICU might be able to play a role in ICUs that do not have 24/7 intensivist coverage in order to address this problem.

The US based studies suggest that 50-60 ICU beds have to be involved in order to make the programme cost-effective – this requires the participation of 8-12 satellite ICUs in the network. The figures for the Netherlands are not yet known, but due to a different financial structure it is expected that they will be lower. Nevertheless, financing such a tele-ICU will be complex. It would probably be wise to limit the number of tele-ICUs in the Netherlands and therefore to coordinate the development of this service.

Summarized, tele-ICU on its own is not what leads to a decrease in ICU and hospital mortality and LOS, but it is the vehicle for intensivists to reach not only more ICU patients, but also to provide more continuous care. The benefits of tele-ICU are a decrease in the number of transportations (especially air) needed and higher adherence to guidelines. The main disadvantages of tele-ICU are the investment needed and the high maintenance costs. For hospitals that already have high standards of quality the enormous investment of a tele-ICU might not be cost-effective.
References