Teletherapeutic drug administration: closed-loop control of propofol as an example

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With the rapid development of telecommunication in the last years, telemedicine has become more interesting with the perspective of medical support even over long distances and/or in case of restrictedaccess. Telemedicine can be broken into three main categories: store- and-forward, remote monitoring and (real-time) interactive services.
Telediagnostics is a typical example for asynchronous telemedicine by acquiring medical data (like medical images, biosignals etc.) and then transmitting this data to a doctor or medical specialist at aconvenient time for assessment offline. It does not require the presence of both parties at the same time. Remote monitoring enables medical professionals to monitor a patient remotely using varioustechnological devices. This method is primarily used for managing chronic diseases or specific conditions. Interactive telemedicine is the most challenging type as it is characterized by real-time interactions between patient and provider. Remote control of robot-assisted surgery (telesurgery) has been successfully realized in recent years, but teletherapeutic drug administration in anesthesia (teleanaesthesia) hasbeen performed only in experimental setup.
In this lecture, I'll present, as an example for teletherapeutic drug administration in anesthesia, a pilot study [1] which was conducted some years ago in the University Hospitals in Erlangen and Munich, with a distance of about 200 km. The control of drug administration and the monitoring of the electroencephalogram (EEG), are two components of anaesthesia that are well suited to test the concept of teletherapyinanaesthesia. These two components were combined to a closed-loop system where the administration of the intravenous anesthetic propofol was automatically controlled to maintain a defined set point of the EEG effect as therapeutic target. The teletherapeutic system consisted of a computer at the patient site in Munich and a computer at the control site in Erlangen, which were connected via the internet. The patient's EEG signal was sent to the control site computer, where the median frequency (MEF)of the EEG power spectrum was calculated. The propofol infusion, determined by a model-based adaptive feedback algorithm to maintain a MEF of 1.5 to 2 Hz, was sent to the patient site computer connected to the infusion pump. The quality of the control was assessed by the performance error defined as the percentage deviation of the measured MEF from the set point and the necessity of interventions by the anaesthetist at the patient site. The study was performed in 11 patients undergoing general surgery.
The closed-loop administration of propofol lasted 83 ± 52 min. The median performance error (MDPE) was 4.6 ± 4.4 % and the median absolute performance error (MDAPE) was 18.8 ± 5.7 %. From a total number of 10905 transmitted EEG epochs there were 5 epochs with transmission errors, without further consequences for drug control. In one case, teletherapy was stopped because the internet connection was interrupted.
Thus, teletherapeutic drug administration could be realized over a longer distance, but further studies would have to investigate the practicability and safety of teletherapeutic drug control in anaesthesia.
Considering the miniaturization which increases the computational power of local devices, and the regulatory and legal issues of automated drug delivery, it may, however, be questionable whether teletherapeutic closed-loop control will become clinical routine in theforeseeable future.

Reference

[1] Ihmsen H, Naguib K, Schneider G, Schwilden H, Schüttler J,Kochs E: Teletherapeutic drug administration by long distance closed-loop control of propofol. Br J Anaesth 2007; 98(2): 189–95