

KEPLER INTUBATION SYSTEM (KIS) – FIRST INTUBATION ROBOT

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Background: Intubation is one of the most important anesthetic skills. The aim of the present study was to develop a robotic intubation system (Kepler Intubation System, KIS) for oral endotracheal intubation in humans and to determine its feasibility defined as success rate of intubation.

Methods: The KIS (Fig. 1) consists of four main components: a ThrustMaster T.Flight Hotas X joystick (Guillemot Inc., New York, NY, USA), a JACO robotic arm (Kinova Rehab, Montreal, QC, Canada), a Pentax AWS video laryngoscope (Ambu A/S, Ballerup, Denmark), and a software control system. The KIS was developed consisting of a remote control centre (joystick and Intubation cockpit) linked to a standard video laryngoscope via a robotic arm (Fig. 2). The joystick allows simulation of wrist or arm movements of a human operator. The study was structured in two steps. The first step of the study was to determine the success rate of intubation in mannequins in 3 different groups. The first group of 30 intubations was performed with the operator in direct view of the mannequin (Direct View group). The second group of 30 intubations was performed with the operator unable to see the mannequin (Indirect View group). Thirty semi-automated intubations were also performed where the robotic system replayed a trace of a previously recorded intubation maneuver (Semi-automated group). The second step of the study assessed the success rate in humans. Success rate of intubation and intubation times were measured in both mannequins and humans. Data are shown as median (interquartiles; min, max) and categorical data. Trends were analyzed using linear regression.

Results: In mannequins, all intubations were successful at first attempt. The mean intubation times were 46(18) s, 51(19) s, and 41(1) s for the Direct View, Indirect View, and Semi-automated group, respectively. Both the Direct and Indirect View groups had a negative slope, denoting that each successive trial required less time. The Semi-automated group had a slope of 0 and a low standard deviation of 1 s, illustrating the high reproducibility of automated intubations (Fig. 3). During the second step of the study, 12 patients aged 66 years were included. Intubation was successful in 12 out of 13 patients at a total time of 93 s (87, 109; 76, 153) (Table 1). In one patient, fogging of the video-laryngoscope prevented intubation using KIS.

Conclusions: We conclude that a robotic intubation system was developed that can even allow remote intubations. We present the first human testing for oral endotracheal intubation. Success rate was high at 91%. Future studies are needed to further evaluate performance and safety of such a system.

