Eye tracking technology to improve communication with intubated critical care patients: a randomized study

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Research Article

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Abstract

Purpose: Communication with patients undergoing mechanical ventilation in the intensive care unit represents a challenge. The aims of the study were (1) to describe communication difficulties related to mechanical ventilation as experienced by caregivers and patients, and (2) to compare the use of a conventional low-tech communication board and a high-tech eye tracking technology-based device in order to improve communication effectiveness of mechanically ventilated patients in intensive care.

Methods: This prospective study consisted of a descriptive cross-sectional part describing the communication difficulties in the intensive care unit and an experimental randomized crossover part comparing the use of two technologically opposed augmentative and alternative communication interfaces. A mixed method approach was applied with a quantitative primary method and a qualitative complementary method.

Results: A total of 101 caregivers and 44 patients participated. Regarding the descriptive part, the communication difficulty analysis confirmed that mechanical ventilation constitutes a major problem in patient-caregiver communication. Regarding the quantitative experimental part, the treatment effects on transmitted messages quantity (2 median messages per exchange for the board versus 4 median messages per exchange for the eye tracking, $p < 0.0001$), success rate (80% for the board versus 100% for the eye tracking, $p < 0.05$) and patient satisfaction (68% negative satisfaction level for the board versus 100% positive satisfaction level for eye tracking, $p < 0.0001$) were significant. Regarding the qualitative experimental part, the communication content covered 8 themes for the board compared to 9 themes for the eye tracking and he use difficulties included 4 categories for the board as well as for the eye tracking.

Conclusion: The eye tracking device may improve communication effectiveness of mechanically ventilated patients compared to the conventional communication board, both quantitatively and qualitatively.

Background

Communication difficulties represent an important problem for mechanically ventilated patients, relatives and caregivers in intensive care units (ICUs) (1). Sedation use associated to mechanical ventilation (MV) has considerably decreased both in duration and intensity over the last decades (2–5). Consequently, an increasing proportion of mechanically ventilated patients are awake and unable to speak (6). Among ICU patients, 40% require invasive MV by an endotracheal tube or tracheostomy which both impair verbal communication (7). Gestural deprivation is added to speech deprivation in a significant proportion of patients, due to muscle wasting and ICU acquired weakness (8,9). Communication difficulties, pain and discomfort are the predominant sources of distress reported by patients under MV (10,11). Only about 5% of the messages transmitted by mechanically ventilated patients are correctly received and understood by the caregivers, indicating that comprehension difficulties are added to the communication difficulties reported by 50% of the patients under MV (12,13). The lack of patients' participation in care is reported by

47% of mechanically ventilated patients and the information received about their health status are qualified as insufficient by 64% of them (10). Communication difficulties in healthcare are associated with an increased risk of patient safety issues (14,15). Furthermore, the inability to verbalize needs and the lack of information are associated with negative emotional reactions: aggressivity, anxiety, depression, fear, frustration, insecurity, loneliness, stress and post-traumatic stress disorder (16–19). Caregivers also report the negative impact of communication difficulties related to MV on work satisfaction and on the quality of care provided to patients, particularly by limiting the exchange of clinically relevant information (20). Augmentative and alternative communication (AAC) is the generic term which refers to a set of communication strategies used to compensate a language production deficiency (21). AAC strategies include both non-assisted and assisted techniques: non-assisted techniques involve the components of non-verbal communication (facial expressions, body posture, gestures, silent articulation, ...) and assisted techniques include the use of low- and high-tech interfaces. Low-tech AAC interfaces cover basic supports such as writing materials, communication boards and pain charts, in contrast to high-tech AAC interfaces covering advanced supports such as computerized communication applications, eye tracking and speech generation devices (3,22). Among these techniques, the communication board and high-tech AAC interfaces appear to provide the highest degree of utility according to the existing literature (23). The aims of the study were (1) to describe communication difficulties related to mechanical ventilation as experienced by ICU caregivers and patients, and (2) to compare the use of a conventional low-tech communication board and a high-tech eye tracking technology-based device to improve communication effectiveness with intubated ICU patients.

Material And Methods

Trial Design

This prospective study consisted of a descriptive cross-sectional part describing the communication difficulties in ICU and an experimental randomized crossover part comparing the use of two technologically opposed AAC interfaces (Fig. 1). A mixed-method approach was applied with the quantitative method as primary method and the qualitative method as complementary method. The computer-generated randomization followed a 1:1 ratio and participants were then assigned to the interventions by the investigator (ES).

Participants

The study was performed in the 32 beds ICUs of the Charleroi University Hospital (CHU Charleroi, Belgium). The caregivers staff included 85 nurses, 2 orderlies, 5 physiotherapists and 14 physicians. The inclusion criteria were as follows: working in the ICUs for the caregivers and being hospitalized in the ICUs, awake with a Richmond Agitation-Sedation Scale (RASS) between “restless” (+ 1) and “drowsy” (-1) (24), age of 18 years or older and French speaker for the patients. The exclusion criteria were lack of consent for both populations and severe visual impairment (e.g., blindness) for the patients. The sample size of caregivers and patients was defined by convenience given the exploratory nature of the study.

Intervention

The low-tech interface was the communication board commonly used at the study site and the high-tech device was an innovative eye tracking technology-based interface (Fig. 2). The communication board provides simple messages based on orthographic and iconic content. The eye tracking computer-based system enables the production and construction of simple or complex messages (including word processing with spelling suggestions and voice synthesis), also based on orthographic and iconic content. Regarding the selection modalities, the communication board relies on a manual selection of the items whereas the eye tracking device enables a selection by the gaze through a continuous analysis of the eye movements determining the gaze direction on the computer screen in real time (25).

Data Collection

The descriptive part of the study evaluated the communication difficulties related to MV by using the "state of the art questionnaire" in the caregiver population and the "ease of communication scale" in the patient population beforehand to the experimental part. The "state of the art questionnaire" (supplementary material A) is a self-administered questionnaire assessing the difficulties to communicate with intubated or tracheostomized patients, the avoidance of interactions with patients, the perception of the help that could be provided by AAC systems and the interest in learning to use these systems. The “ease of communication scale” (supplementary material B) is a multidimensional scale completed through an assisted interview and covering the difficulty to be understood; to communicate physical needs, thoughts, and feelings with notably relatives, nurses and physicians; and to ask questions about care and health status (26).

The experimental part of the study measured the communication effectiveness indicators (Table 1) regarding the use of the communication board and the eye tracking device by using the "intervention form". The "intervention form" (supplementary material C) was completed for each interface at two timepoints by the investigator (ES) during the use of the interfaces to collect the number of messages transmitted, the success rate, the communication content as well as the difficulties of use encountered, and subsequently after using the interfaces through an assisted interview to assess the level of satisfaction of the patient.

The self-developed "state of the art questionnaire" and "intervention form" were designed, notably from the existing literature to cover the purposes of the present research.

Caregiver and patient characteristics were also collected including age, gender, profession specifically for caregivers and Simplified Acute Physiology Score III (SAPS III) specifically for patients.

Table 1: Communication effectiveness indicators

The communication effectiveness indicators provided a basis for comparing AAC interfaces by structuring the evaluation of each communication exchange. In the context of this study, a communication exchange is characterized as a transmission of information between the patient and the caregiver.

Indicators	Operational description
Messages transmitted	Quantitative measurement of messages transmitted per communication exchange: 0, …, n message(s).
Success rate	Binary measurement of message transmission success: 0 = no message transmitted, 1 = message transmitted (at least one).
Patient satisfaction	Quantitative measurement of patient satisfaction regarding communication interfaces: 1 = dissatisfied, 2 = not satisfied, 3 = satisfied, 4 = very satisfied (Likert scale).
Communication content	Qualitative measurement of communication exchange content: non-numerical data.
Difficulties of use	Qualitative measurement of difficulty in using alternative communication interfaces: non-numerical data.

Data Analysis

The numerical data corresponding to the level of communication difficulty, quantity of messages transmitted, success rate and patient satisfaction were analyzed quantitatively using R software (version 2016 3.5.3) (27). The Gaussian distribution of the quantitative data was estimated by mean/median comparison, histogram symmetry, quantile-quantile distribution and shapiro-wilk test. Statistical analysis of the crossover variables (treatment-period interaction, period effect, and treatment effect) were performed using the nonparametric Mann-Whitney test. A p-value less than 0.05 was considered significant.

The non-numerical data corresponding to communication content and difficulties in using the interfaces were analyzed qualitatively by grouping communication content into themes and difficulties of use into categories.

Quality appraisal

The methodological quality of the study was examined according to the Mixed Methods Appraisal Tools (MMAT) criteria (28) and reporting follows the Consolidated Standards of Reporting Trials (CONSORT) statement (29). The MMAT provides a critical appraisal of quantitative and qualitative studies by focusing on methodological criteria related to the accuracy and adequacy of the research framework (28).

Results

A total of 101 caregivers and 44 patients were included between February and June 2019 (Fig. 3). Professional characteristics of the included caregivers are presented in Table 2 and clinical characteristics of the included patients are presented in Table 3.

Table 2: Professional characteristics of the caregivers

Results are presented in Mean±Standard deviation and in counts (%).

Variables	**Total** **n = 101**
Age (years)	34±9
Gender	
Male	37 (37%)
Female	64 (63%)
Profession	
Nurses	81 (80%)
Orderlies	2 (2%)
Physicians	14 (14%)
Physiotherapist	4 (4%)

Table 3: Clinical characteristics of the patients

Results are presented in Mean±Standard deviation, in counts (%) and Median (Interquartile Range).

Variables	Total n = 44
Age (years)	64±11
Gender	
Male	27 (61%)
Female	17 (39%)
Admission diagnosis	
Cardiac surgery	8 (18%)
Shock	5 (11%)
Polytrauma	1 (2%)
Respiratory failure	21 (48%)
Sepsis	2 (4%)
Cardiac arrest	3 (7%)
Others	4 (9%)
SAPS III score	52,5 (41-66)
RASS	
RASS -1	19 (43%)
RASS 0	21 (48%)
RASS +1	4 (9%)
Treatments	
Benzodiazepines	5 (11%)
Propofol	4 (9%)
Morphine	4 (9%)
Dialysis	2 (5%)
Catecholamines	4 (9%)
Other	25 (57%)

Descriptive part

Communication was considered as difficult with intubated and tracheostomized patients for 69 and 65 caregivers respectively (68% and 64%). The implementation of AAC systems was identified as a potential help for 98 of them (97%). Concerning the interest in training on the use of tools facilitating communication with mechanically ventilated patients, 98 caregivers (97%) responded positively. The avoidance of interaction with mechanically ventilated patients was also reported by 67 caregivers (66%).

Communicating without being able to speak was considered difficult for 35 patients (80%). Getting understood without being able to speak was perceived as difficult for 39 patients (89%). The transmission of physical needs, thoughts and feelings was reported to be difficult for 29, 33 and 32 patients (66%, 75% and 73%) respectively. Communication was described as difficult with doctors for 24 patients (55%), with nurses for 22 patients (50%) and with relatives for 27 patients (61%). Asking questions about care and health status was considered as difficult for 36 patients (82%). No item was rated as “not difficult at all”.

Experimental part

Communication effectiveness indicators were extracted from the 88 communication exchanges (44 exchanges per interface). The “interface” effects on transmitted messages quantity ($p = 0{,}00003$), success rate ($p = 0{,}002$) and patient satisfaction ($p = 0.00004$) were significant (highly significant for transmitted messages quantity and patient satisfaction). No period effects or treatment-period interactions were observed for these indicators ($p > 0.05$). The median quantity of messages transmitted per exchange corresponded to 2 messages (Inter Quartile Range (IQR): 2–2) through the communication board and to 4 messages (IQR: 3–5) through the eye tracking device. The success rate of the communication exchanges reached 80% for the communication board and 100% for the eye tracking device. The level of satisfaction regarding the communication board was positive for 14 patients (32% were "satisfied") but negative for 30 patients (68% were "not satisfied") and the level of satisfaction regarding the eye tracking device was positive for all the 44 patients (52% were "satisfied" and 48% "very satisfied"). No association was reported between these indicators and SAPS III score, age or gender.

The communication content by the communication board (supplementary material D) covered the themes “breathing” in 9 exchanges (20%), “pain” in 8 exchanges (18%), “nutrition-hydration” in 8 exchanges (18%), “installation” in 4 exchanges (9%), “psychological state” in 3 exchanges (7%), “hygiene” in 3 exchanges (7%), “rest” in 2 exchanges (5%) and “thermoregulation” in 1 exchange (2%). The communication content by the eye tracking device (supplementary material D) covered the themes “breathing” in 23 exchanges (52%), “pain” in 10 exchanges (23%), “nutrition-hydration” in 10 exchanges (23%), “installation” in 10 exchanges (23%), “psychological” state in 7 exchanges (16%), “hygiene” in 7 exchanges (16%), “rest” in 7 exchanges (16%), “environment” in 3 exchanges (7%) and “thermoregulation” in 2 exchanges (5%).

The difficulties of use for the communication board (supplementary material E) included the categories "difficulty to select the items" for 21 exchanges (48%), "difficulty to visualize items" for 8 exchanges (18%), "insufficient items" for 11 exchanges (25%) and “difficulty to understand the utilization" for 3 exchanges (7%). The difficulties of use for the eye tracking device (supplementary material E) included the categories "difficulty to detect eye gaze" for 12 exchanges (27%), "difficulty to select the items" for 10 exchanges (23%), “difficulty to understand the utilization" for 8 exchanges (18%) and "difficulty to install the device" for 2 exchanges (5%). Difficulties in using the communication board occurred in 43 exchanges (97%) and difficulties in using the eye tracking device occurred in 32 exchanges (73%).

Discussion

The present research provides (1) an insightful description of the communication difficulties related to MV experienced by both caregivers and patients, and (2) a previously unexplored perspective by comparing the use of two technologically opposed AAC interfaces, thereby covering a notable gap in the literature about the most appropriate AAC strategy in the ICU (3,23). The results confirmed that MV constitutes a major problem in patient-caregiver communication (1,26,30) and suggest that eye tracking technology may improve the communication of mechanically ventilated patients beyond the communication board, regarding the quantity of messages transmitted, the success rate of transmissions, the satisfaction of patient and the communication content despite the difficulties of use encountered.

Beside the communication difficulties experienced with intubated and tracheotomized patients, the fear of not being able to understand patients also seems to lead caregivers to avoid communication exchanges. The AAC systems seemed to be perceived positively by the caregivers, particularly regarding the help that AAC systems could provide and the interest in learning to use these systems in the ICU. The inability of patients to get understood and to ask questions about their health status or care appeared to be the leading cause of communication difficulties. Moreover, the difficulty to communicate with relatives seemed to be more present than the difficulty to communicate with doctors and nurses.

The existing literature associates AAC interfaces use with an improvement of communication through increasing the communication interactions and satisfaction for patients as well as caregivers (31–33). Through the results of the present study, such improvement of communication was more important when using the eye tracking device given that the quantity of transmitted messages, the success rate and the level of patient satisfaction were significantly higher than with the communication board. Furthermore, previous studies revealed that communication with a high-tech AAC interface covered more fundamental needs than basic communication without AAC support (34,35). The fundamental needs seemed, through this study, to be covered by the low- and high-tech interfaces but the latter also extends beyond the dimension of the fundamental needs to the critical care environment. Indeed, the results highlighted 8 common themes between the communication board and the eye tracking device covering fundamental needs (i.e., breathing, pain, nutrition-hydration, installation, psychological state, hygiene, rest, thermoregulation), but also a theme exclusively covered by the eye tracking device (i.e., interaction with the environment). Although AAC interfaces are intended to support communication, difficulties of use can also be encountered. As highlighted in a recent scoping review, barriers to AAC use may be related to caregivers' communication skills, environmental context of critical care and material resources available

(36). The barriers considered in the literature concern the implementation of AAC communication in healthcare settings, whereas this study provided a description of specific difficulties in using two AAC interfaces technologies. The difficulties of use involved 2 common categories for both interfaces (i.e., the difficulty to understand the utilization and to select the items) and 2 specific categories for the communication board or the eye tracking device (i.e., difficulty to visualize items and insufficient items for the communication board, difficulty to detect eye gaze and difficulty to install the device for the eye tracking). However, the difficulties of use for the high-tech AAC interface were not systematically encountered and did not hinder the transmission of the messages, unlike the difficulties encountered with the low-tech AAC interface. The principal difficulties in using the communication board and the eye tracking device were, respectively, the selection of the items and the detection of eye gaze. The gestural deprivation inherent to muscle wasting and ICU acquired weakness could explain the difficulty to select the items manually (8,9) and the fluctuating arousal state in ICU patients could explain the difficulty to detect eye gaze (and by extension, the difficulty to select the items through the gaze) by notably limiting eyelid opening (9).

The implementation of AAC strategies in clinical settings requires training of caregivers as well as availability of equipment (15,37,38). As previously explained, most of the caregivers involved were interested in learning to use the eye tracking device. Several training sessions were therefore provided by the investigator during the study, reaching more than half of the ICUs staff. The AAC interfaces should also be available at all bedsides, but the accessibility may depend on the level of technology (15). Indeed, the communication board seems to be more accessible than the eye tracking device, notably because of the reduced cost of a printed paper interface compared to the costs of the different components of the technological interface. Assisted techniques currently dominate in ICUs, so patients completely depend on the assistance of caregivers to communicate (15,37,38). However, the eye tracking device enable the patient to communicate independently but the interface must beforehand be installed and calibrated by caregivers (15,38,39).

Although the results seem very promising, this study presents some limitations to consider. The study involved a sample of 44 patients, thus potentially limiting generalization to the general population. However, the patient sample recruited in this study turns out to be larger than the patient samples of previous, basically pilot, studies evaluating high-tech interfaces in ICUs (34,40,41). The number of patients recruited over a relatively long period of 10 months also suggests a limited target population. The perspectives of caregivers and relatives were not represented, although this information would have been interesting and very relevant to enhance the contribution of the present study in the search for the most effective AAC interface in ICU. The qualitative method may have induced a subjective dimension in the data processing through thematization and categorization. Nevertheless, the sequential procedure structuring the qualitative analysis and the evaluation of the methodological quality through the MMAT permitted to control this potential subjectivity. The monocentric setting may also limit the transferability of the results to other ICU environments. And finally, the communication exchanges were evaluated by an investigator, but any subjectivity and interpretation were prevented by clearly defined judgement criteria specified in the protocol. Future comparative studies should therefore examine the perspectives of caregivers as well as relatives regarding the use of AAC strategies in ICUs and also consider a multicenter setting.

Conclusion

This study highlights the communication difficulties associated with MV in the ICU and demonstrates that an eye tracking technology-based device may improve the communication effectiveness of mechanically ventilated patients both quantitatively and qualitatively. Furthermore, this research contributes to the development of new knowledge about communication with mechanically ventilated patients in the ICU and provides a previously unstudied perspective by comparing low- and high-tech AAC interfaces. The use of high-tech interfaces such as the eye tracking device presently evaluated sends a promising signal for improving patient-caregiver communication in the ICU.

Abbreviations

ICU
intensive care unit (ICUs:intensive care units)
MV
mechanical ventilation
AAC
augmentative and alternative communication
IQR
Inter Quartile Range

Declarations

Ethics approval

The study protocol was approved by the Ethics Committee of the Hospital of Liège as Central Committee and the Hospital of Charleroi as Local Committee (number: B70720183767, reference: 2018/268). The information and consent documents intended for caregivers and patients were validated by both Ethics Committees. Written informed consent was obtained from all participants (caregivers and patient's legal representative) included in this study. All procedures performed through this study were in accordance with the 1964 Helsinki Declaration and its later amendments.

Availability of data and material

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Code availability

Not applicable.

Competing interests

S.E. declares having received research support, consultancies, travel reimbursements and speaker fees from Aerogen Ltd and Fisher & Paykel healthcare. The other authors do not declare competing interest.

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Authors' contributions

L.B-C. and S.E. initiated the research project. L.B-C., S.E. and Y.M. supervised the project and provided advices for scientific writing. E.S. collected and analyzed data. E.S wrote the manuscript draft. All authors have read and approved the final manuscript.

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Additional information

"Take-home message"

Communication of mechanically ventilated patients in intensive care units may be significantly improved by using high-tech eye tracking technology-based communication device.

"Tweet"

High-tech eye tracking technology to improve communication of mechanically ventilated patients: evidence is emerging.

References

1. Ten Hoorn S, Elbers PW, Girbes AR, Tuinman PR. Communicating with conscious and mechanically ventilated critically ill patients: a systematic review. Crit Care Lond Engl. 2016 Oct 19;20(1):333.
2. Kelly FE, Fong K, Hirsch N, Nolan JP. Intensive care medicine is 60 years old: the history and future of the intensive care unit. Clin Med. 2014 Aug;14(4):376–9.

3. Karlsen MMW, Ølnes MA, Heyn LG. Communication with patients in intensive care units: a scoping review: Communication with patients in intensive care units. Nurs Crit Care. 2019 May;24(3):115–31.
4. Kjeldsen CL, Hansen MS, Jensen K, Holm A, Haahr A, Dreyer P. Patients' experience of thirst while being conscious and mechanically ventilated in the intensive care unit: Patients' experience of thirst while being conscious and mechanically ventilated. Nurs Crit Care. 2018 Mar;23(2):75–81.
5. Leung CCH, Pun J, Lock G, Slade D, Gomersall CD, Wong WT, et al. Exploring the scope of communication content of mechanically ventilated patients. J Crit Care. 2018 Apr;44:136–41.
6. Happ MB, Seaman JB, Nilsen ML, Sciulli A, Tate JA, Saul M, et al. The number of mechanically ventilated ICU patients meeting communication criteria. Heart Lung. 2015 Jan;44(1):45–9.
7. Wunsch H, Wagner J, Herlim M, Chong DH, Kramer AA, Halpern SD. ICU Occupancy and Mechanical Ventilator Use in the United States*: Crit Care Med. 2013 Dec;41(12):2712–9.
8. Jolley SE, Bunnell AE, Hough CL. ICU-Acquired Weakness. Chest. 2016 Nov;150(5):1129–40.
9. Holm A, Dreyer P. Use of Communication Tools for Mechanically Ventilated Patients in the Intensive Care Unit. CIN Comput Inform Nurs. 2018 Aug;36(8):398–405.
10. Alasad JA, Abu Tabar N, Ahmad MM. Patients' experience of being in intensive care units. J Crit Care. 2015 Aug;30(4):859.e7-859.e11.
11. Holm A, Dreyer P. Intensive care unit patients' experience of being conscious during endotracheal intubation and mechanical ventilation: Being conscious during endotracheal intubation in the ICU. Nurs Crit Care. 2017 Mar;22(2):81–8.
12. Guttormson JL, Bremer KL, Jones RM. "Not being able to talk was horrid": A descriptive, correlational study of communication during mechanical ventilation. Intensive Crit Care Nurs. 2015 Jun;31(3):179–86.
13. Otuzoğlu M, Karahan A. Determining the effectiveness of illustrated communication material for communication with intubated patients at an intensive care unit: Communication with intubated patients. Int J Nurs Pract. 2014 Oct;20(5):490–8.
14. Sharpe B, Hemsley B. Improving nurse–patient communication with patients with communication impairments: hospital nurses' views on the feasibility of using mobile communication technologies. Appl Nurs Res. 2016 May;30:228–36.
15. Handberg C, Voss AK. Implementing augmentative and alternative communication in critical care settings: Perspectives of healthcare professionals. J Clin Nurs. 2018 Jan;27(1–2):102–14.
16. Baumgarten M, Poulsen I. Patients' experiences of being mechanically ventilated in an ICU: a qualitative metasynthesis. Scand J Caring Sci. 2015 Jun;29(2):205–14.
17. Tate JA, Devito Dabbs A, Hoffman LA, Milbrandt E, Happ MB. Anxiety and Agitation in Mechanically Ventilated Patients. Qual Health Res. 2012 Feb;22(2):157–73.
18. Noguchi A, Inoue T, Yokota I. Promoting a nursing team's ability to notice intent to communicate in lightly sedated mechanically ventilated patients in an intensive care unit: An action research study. Intensive Crit Care Nurs. 2019 Apr;51:64–72.

19. Tembo AC, Higgins I, Parker V. The experience of communication difficulties in critically ill patients in and beyond intensive care: Findings from a larger phenomenological study. Intensive Crit Care Nurs. 2015 Jun;31(3):171–8.
20. IJssennagger CE, Ten Hoorn S, Van Wijk A, Van den Broek JM, Girbes AR, Tuinman PR. Caregivers' perceptions towards communication with mechanically ventilated patients: The results of a multicenter survey. J Crit Care. 2018 Dec;48:263–8.
21. Murray J, Goldbart J. Augmentative and alternative communication: a review of current issues. Paediatr Child Health. 2009 Oct;19(10):464–8.
22. Mirenda P. Toward Functional Augmentative and Alternative Communication for Students With Autism: Manual Signs, Graphic Symbols, and Voice Output Communication Aids. Lang Speech Hear Serv Sch. 2003 Jul;34(3):203–16.
23. Zaga Charissa J., Berney Sue, Vogel Adam P. The Feasibility, Utility, and Safety of Communication Interventions With Mechanically Ventilated Intensive Care Unit Patients: A Systematic Review. Am J Speech Lang Pathol. 2019 Aug 9;28(3):1335–55.
24. Sessler CN, Gosnell MS, Grap MJ, Brophy GM, O'Neal PV, Keane KA, et al. The Richmond Agitation–Sedation Scale. Am J Respir Crit Care Med. 2002;166:1338–44.
25. Bodet-Contentin L, Gadrez P, Ehrmann S. Eye-tracking and speech-generating technology to improve communication with intubated intensive care unit patients: initial experience. Intensive Care Med. 2018 May;44(5):676–7.
26. Martinho CIF, Rodrigues ITRM. Communication of mechanically ventilated patients in intensive care units. Rev Bras Ter Intensiva [Internet]. 2016 [cited 2019 Apr 6];28(2). Available from: http://www.gnresearch.org/doi/10.5935/0103-507X.20160027
27. R Core Team. R: a language and environment for statistical computing. [Internet]. 2018. Available from: www. R-project.org
28. Hong QN, Fàbregues S, Bartlett G, Boardman F, Cargo M, Dagenais P, et al. The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. Educ Inf. 2018 Dec 18;34(4):285–91.
29. Schulz KF, Altman DG, Moher D, for the CONSORT Group. CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials. BMJ. 2010 Mar 23;340(mar23 1):c332–c332.
30. Mortensen CB, Kjær MBN, Egerod I. Caring for non-sedated mechanically ventilated patients in ICU: A qualitative study comparing perspectives of expert and competent nurses. Intensive Crit Care Nurs. 2019 Jun;52:35–41.
31. Happ MB, Garrett KL, Tate JA, DiVirgilio D, Houze MP, Demirci JR, et al. Effect of a multi-level intervention on nurse–patient communication in the intensive care unit: Results of the SPEACS trial. Heart Lung. 2014 Mar;43(2):89–98.
32. Carruthers H, Astin F, Munro W. Which alternative communication methods are effective for voiceless patients in Intensive Care Units? A systematic review. Intensive Crit Care Nurs. 2017 Oct;42:88–96.

33. Modrykamien AM. Strategies for communicating with conscious mechanically ventilated critically ill patients. Bayl Univ Med Cent Proc. 2019 Oct 2;32(4):534–7.
34. Miglietta MA, Bochicchio G, Scalea TM. Computer-Assisted Communication for Critically Ill Patients: A Pilot Study: J Trauma Inj Infect Crit Care. 2004 Sep;57(3):488–93.
35. Ull C, Hamsen U, Weckwerth C, Schildhauer TA, Gaschler R, Waydhas C, et al. Approach to the basic needs in patients on invasive ventilation using eye-tracking devices for non-verbal communication. Artif Organs. 2021 Oct 12;
36. Istanboulian L, Rose L, Gorospe F, Yunusova Y, Dale CM. Barriers to and facilitators for the use of augmentative and alternative communication and voice restorative strategies for adults with an advanced airway in the intensive care unit: A scoping review. J Crit Care. 2020 Jun;57:168–76.
37. Holm A, Viftrup A, Karlsson V, Nikolajsen L, Dreyer P. Nurses' communication with mechanically ventilated patients in the intensive care unit: Umbrella review. J Adv Nurs. 2020 Nov;76(11):2909–20.
38. Dithole K, Sibanda S, Moleki MM, Thupayagale-Tshweneagae G. Exploring Communication Challenges Between Nurses and Mechanically Ventilated Patients in the Intensive Care Unit: A Structured Review: Communication Between Nurses and Mechanically Ventilated ICU Patients. Worldviews Evid Based Nurs. 2016 Jun;13(3):197–206.
39. Koszalinski RS, Tappen RM, Hickman C, Melhuish T. Communication Needs of Critical Care Patients Who Are Voiceless: CIN Comput Inform Nurs. 2016 Aug;34(8):339–44.
40. Maringelli F, Brienza N, Scorrano F, Grasso F, Gregoretti C. Gaze-controlled, computer-assisted communication in Intensive Care Unit: 'speaking through the eyes'. Minerva Anestesiol. 2013 Feb;79(2):165–75.
41. Garry J, Casey K, Cole TK, Regensburg A, McElroy C, Schneider E, et al. A pilot study of eye-tracking devices in intensive care. Surgery. 2016 Mar;159(3):938–44.

Figures

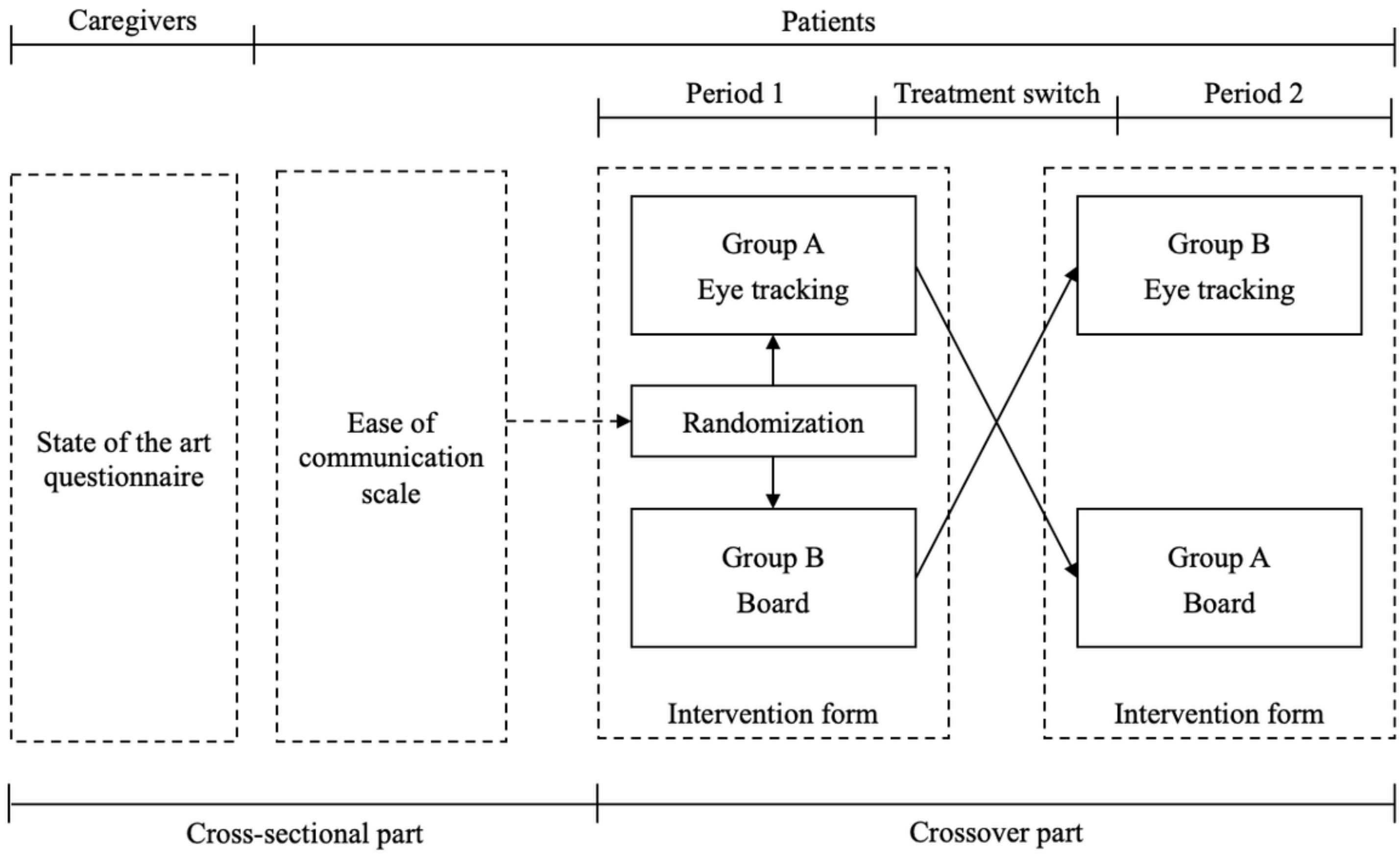

Figure 1

Schematic representation of the study design

2.a Communication board

2.b Eye tracking

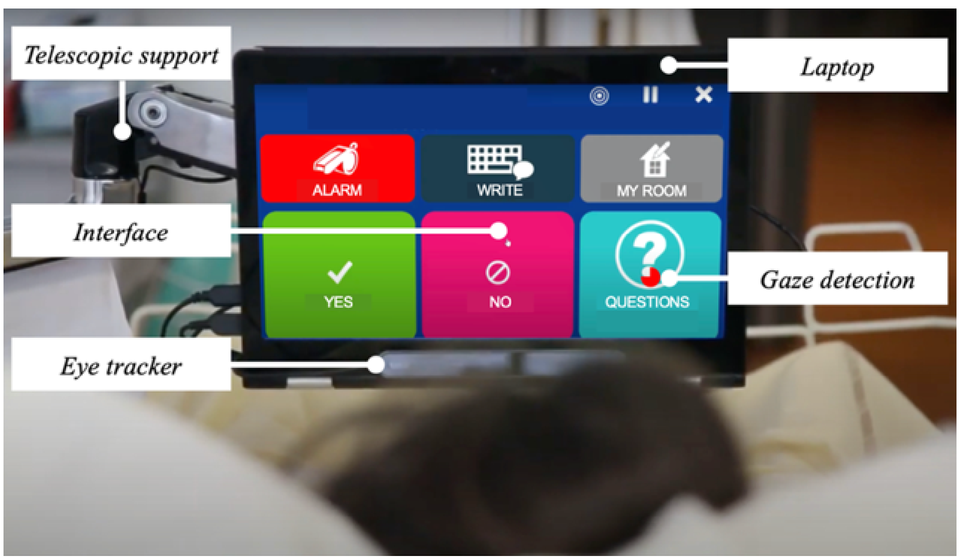

Figure 2

Communication interfaces - 2.a Communication board - 2.b Eye tracking

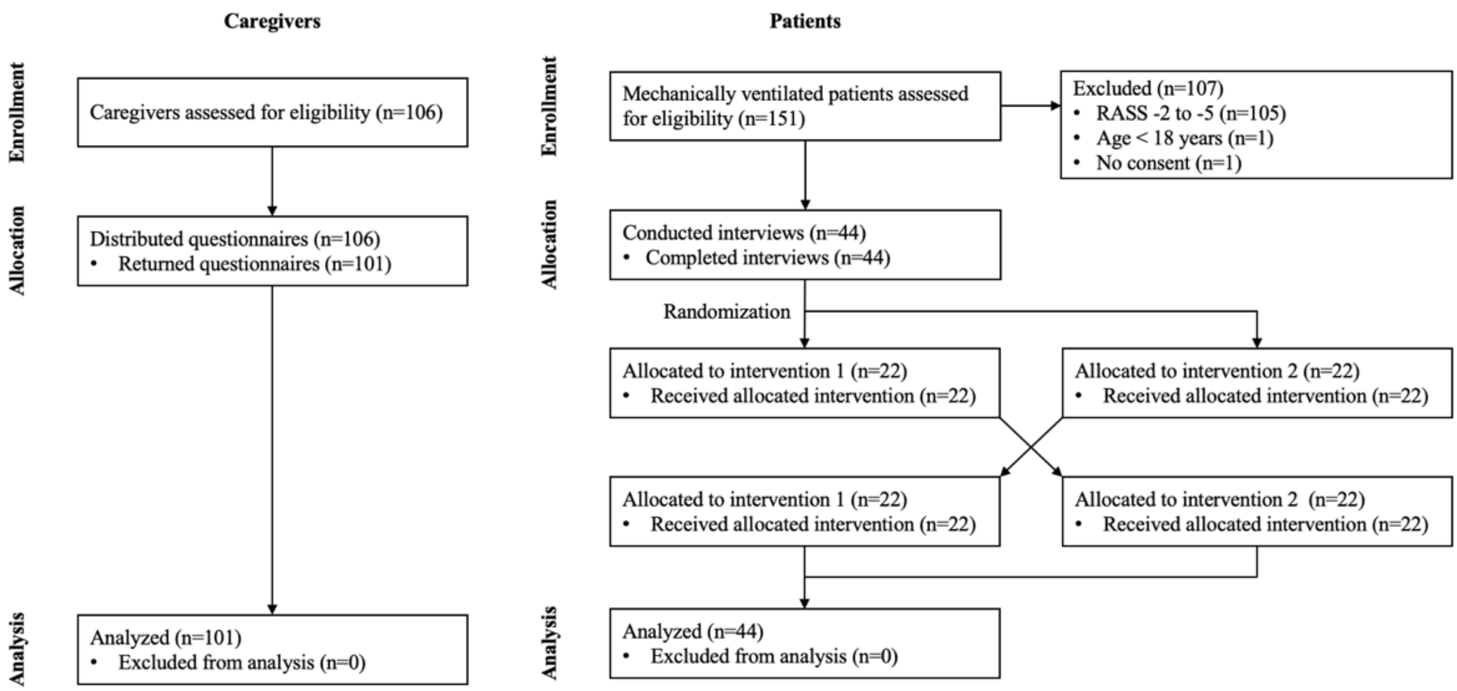

Figure 3

Participant flow diagram

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementarymaterial.docx