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## **Positive communication behaviour during handover and team-based clinical performance in critical situations: a simulation randomised controlled trial**

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**Running title:** Positive communication and team performance

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**Keywords:** clinical performance; communication behaviour; high-fidelity simulation; positive communication; stress response; teamwork

**Editor's key points**

## Abstract

**Background:** Positive communication behaviour within anaesthesia teams may decrease stress response and improve clinical performance. We aimed to evaluate the effect of positive communication during medical handover on the subsequent team-based clinical performance in a simulated critical situation. We also assessed the effect of positive communication behaviour on stress response.

**Methods:** This single-centre randomised controlled trial involved anaesthesia teams composed of a resident and a nurse in a high-fidelity scenario of anaesthesia-related paediatric laryngospasm after a standardised handover. During the handover, similar information was provided to all teams, but positive communication behaviour was adopted only for teams in the intervention group. Primary outcome was team-based clinical performance, assessed by an independent blinded observer, using video recordings and a 0-100 point scenario-specific scoring tool. Three categories of tasks were considered: safety checks before the incision, diagnosis/treatment of laryngospasm, and crisis resource management/non-technical skills. Individual stress response was monitored by perceived level of stress and heart rate variability.

**Results:** The clinical performance of 64 anaesthesia professionals (grouped into 32 teams) was analysed. The mean (SD) team-based performance score in the intervention group was 44 (10) points, versus 35 (12) in the control group (difference +8.4, CI<sub>95%</sub> [0.4 to 16.4], P=0.04). The effects were homogenous over the three categories of tasks. Perceived level of stress and heart rate variability were not significantly different between groups.

**Conclusions:** Positive communication behaviour between healthcare professionals during medical handover improved team-based performance in a simulation-based critical situation.

**Trial registry number:** NCT03375073 (ClinicalTrials.gov)

Enhancing teamwork improves clinical performance and patient safety, particularly in anaesthesia.<sup>1,2</sup> Team-based crisis management is strongly **influenced** by a set of social and cognitive skills grouped under the term “Crisis Resource Management”.<sup>3-5</sup> Effective communication is one of its central components,<sup>6,7</sup> and both verbal<sup>8-10</sup> and nonverbal<sup>11-13</sup> aspects of communication within a team appear essential.<sup>14</sup> Coping with stress is also fundamental for crisis management to avoid disruption of cognitive processes<sup>15</sup> and reduction of clinical performance.<sup>16, 17</sup>

Positive communication behaviour is a technique aiming to optimise both the verbal and nonverbal components of the communication process. It consists, on the verbal aspect, of using positive suggestions without any form of negation; and on the nonverbal aspect, of using a calm and slow voice, looking in the eyes, and displaying a smiling face, an open posture and appropriate clothing.<sup>18</sup> Positive communication behaviour is known to reduce stress response and its consequences in patients,<sup>19</sup> but its potential benefit in healthcare professionals themselves remains to be studied.

Laryngospasm is a frequent potentially serious complication of paediatric anaesthesia.<sup>20</sup> This critical incident is well-suited for a short simulation and requires essential technical and nontechnical skills.<sup>21</sup>

**The primary objective of the present study was to evaluate the effect of positive communication behaviour during medical handover on subsequent team-based clinical performance in a standardised simulated scenario of anaesthesia-related paediatric laryngospasm. The secondary objective was to evaluate its effect on health professionals’ acute psychological and physiological stress response.**

## **Methods**

### *Population and setting*

**This study was a prospective randomised (1:1) controlled trial with two parallel arms, blinded evaluation and a hypothesis of superiority. The protocol was preregistered on [clinicaltrials.gov](https://clinicaltrials.gov) (protocol ID: NCT03375073). Approval was obtained from the ethics committee of the French Society of Anaesthesia & Intensive Care Medicine (IRB 00010254-2019-066) on 19 May 2019. The study was**

conducted at the medical simulation centre of the Grenoble Alpes University Hospital (Alps Research Assessment and Simulation Centre) during the 2017-2018 academic year. The study followed the recommendations of the International Committee of Medical Journal Editors (ICMJE), the CONSORT guidelines<sup>22</sup> and its extensions for clustered trials, non-pharmacologic treatment intervention and healthcare simulation research. All subjects were volunteer professionals from the Grenoble-Alpes University Hospital and gave written and informed consent to participate and to be filmed. **Prior to the simulation, participants received a general briefing on room layout and mannequin features and limitations. Confidentiality, kindness and the right to make mistakes were emphasised as fundamental principles of simulation learning and research.** Once the scenario was completed, they received a structured debriefing. The instructor group was composed of certified anaesthetists and residents with a specific medical simulation diploma.

#### *Work scenario*

Our standardised high-fidelity simulated scenario of anaesthesia-related paediatric laryngospasm was derived from a published scenario,<sup>21</sup> and had been repeatedly and successfully tested in our centre. It was constructed and described following the French Society of Simulation in Health (*Société Francophone de Simulation en Santé - SoFraSimS*) guidelines (Appendix 1).<sup>23</sup> It involves a two-person anaesthesia team: an anaesthesia resident and a nurse anaesthetist. Working in pairs is commonplace in France, particularly in paediatric anaesthesia. Before the scenario begins, the team receives from the senior anaesthetist a 1-min handover about the ongoing case (**Table 1**). After the handover, the resident and the nurse are left alone with the surgeon (played by a neutral embedded facilitator) and the anaesthetised patient (mannequin Sim Junior®, Laerdal Medical®, city, Norway). **The senior anaesthetist remains available by telephone.** After a 2-min **time out**, the surgeon makes the skin incision, which is immediately followed by an airway obstruction due to complete laryngospasm and rapid oxygen desaturation. The scenario is stopped when the anaesthesia team, once the incident is resolved, authorises the surgeon to resume the procedure.

### *Development of the clinical performance scoring tool*

A specific scoring tool was previously developed to assess team-based clinical performance in the work scenario. This tool was obtained after a four-step development method. First, the investigators composed a preliminary list of tasks, based on available literature, their experience and the specifics of the scenario. Second, the list was revised, elaborated and weighted by six subject matter experts by means of a targeted modified Delphi survey. Third, the resulting provisional tool was pilot-tested on a sample of simulations and improved accordingly. Fourth, the experts made an ultimate review leading to the final tool.

The final tool (appendix 2) consisted of 22 tasks, divided into three categories corresponding to the main pedagogical objectives of the scenario: “safety checks before the incision”, “diagnosis and treatment of laryngospasm” and “crisis resource management and nontechnical skills”. Each task is associated with a behaviourally-anchored 2 to 4-level rating scale and weighted for a total of 100 points. The tool allows calculation of category-specific performance scores (0-18 point, 0-42.5 point, and 0-39.5 point scales, for “safety checks before the incision”, “diagnosis and treatment of laryngospasm” and “crisis resource management and nontechnical skills”, respectively), and the overall clinical performance score (0-100 point scale).

Inter-rater reliability was studied by having the final tool applied in 8 video-recorded simulations by three independent assessors. The overall intra-class correlation coefficient (ICC, two-way model, absolute agreement, single measures) was 0.85. Category-specific ICCs were 0.87, 0.90 and 0.62 for “safety checks before the incision”, “diagnosis and treatment of laryngospasm” and “crisis resource management and nontechnical skills”, respectively.

### *Study protocol*

Volunteer anaesthesia residents and nurse anaesthetists, **with no previous specific training on laryngospasm and unaware of the scenario**, were randomly paired to form anaesthesia teams. Each

team was then allocated to the intervention or control group using a stratified cluster randomization with a 1:1 allocation ratio. Groups were stratified according to the experience of the teams. “Junior teams” included a year 2-3 resident and a second-year student nurse anaesthetist, while “experienced teams” included a year 4-5 resident and a nurse anaesthetist certified for less than 5 yr and not working in paediatrics. The senior anaesthetist (absent from the scenario) was the only one to know the allocation group. Group allocation was concealed by a coding system (random number sequence), the key of which was disclosed only for the final analysis.

The intervention took place during the handover period, outside the operating room. The teams all took over from a single actor playing the senior anaesthetist (JPicard) who had been previously trained to follow strict rules of verbal and nonverbal communication for this handover. While he transmitted similar standardised information during a similar 1-min period, he adopted different communication behaviour depending on the allocation group. Table 1 describes in detail how the handover was carried out in the two groups. After the handover, the scenario started and was video recorded using two cameras.

#### *Primary endpoint: clinical team-based performance*

The primary endpoint was overall team-based clinical performance in the scenario, assessed by an independent observer (P-MB) blind to group allocation using video recordings and the previously developed scoring tool. The category-specific performance scores were also calculated.

#### *Baseline data and secondary endpoints*

The duration of crisis management, from occurrence of laryngospasm to authorization given to resume the procedure, was measured. The proportion of teams that issued a call for help in a timely manner (*i.e.* before SpO<sub>2</sub> fell to <80%) was examined. Heart rate variability was recorded to assess physiological stress response in each member of the anaesthesia team. Point-by-point heart rate was measured and recorded by a pectoral heart rate monitor (Smart Sensor®, SUUNTO®, Finland)

connected to a dedicated mobile software (CardioMood®, manufacturer, city, state, USA). Sympathetic activation in response to acute stress is associated with a decrease in heart rate variability and thus in SDNN (Standard Deviation Normal to Normal).<sup>24</sup> SDNN was calculated for each participant over 6 relevant consecutive periods: at subjects' arrival (during 5 min), during handover (1 min), during the pre-crisis period of the scenario (2 min), during the crisis period (from 3 to 12 min), during debriefing (from 20 to 30 min), and at discharge (5 min) (Figure 1). Psychological stress response was monitored by perceived level of stress (PLS, on 0-100 Visual Analogue Scale)<sup>25</sup> at arrival, between handover and simulation, between simulation and debriefing, and at discharge (Figure 1). Anxiety was assessed using a validated French version<sup>26</sup> of the State-Trait Anxiety Inventory (STAI, 20 to 80 points).<sup>27</sup> The STAI distinguishes the anxiety felt at a given time (state-anxiety) from anxiety as part of one's personality (trait-anxiety). State-anxiety was measured at subjects' arrival and discharge (Figure 1). Trait-anxiety was measured 15 days before the simulation session, as well as basal stress level, using the French version<sup>28</sup> of the Perceived Stress Scale (PSS, from 10 to 50 points).<sup>29</sup>

### *Statistical Analysis*

With the assumption that the mean (SD) clinical team-based performance score would increase from 45 (10) / 100 points in the control group to 55 (10) / 100 points in the intervention group, a 5%  $\alpha$  risk, a 10%  $\beta$  risk, and a bilateral test, the total number of teams required was 32 (16 per group). All analyses were intention-to-treat, and all statistical tests were bilateral. Analyses were performed with Stata 15® software (Timberlake®, manufacturer, city, UK). A  $P$ -value  $\leq 0.05$  was considered significant.

The distribution of quantitative variable was studied by examining graphic representations (frequency histograms and QQ-plots) and using the Shapiro Wilk's test. Data were then expressed as mean (SD) or median [25<sup>th</sup> to 75<sup>th</sup> percentiles], as appropriate. Student t-test was used to compare team-based clinical performance scores between groups. Results were expressed in terms of



absolute differences in scores and their 95% confidence intervals (95% CI). Duration of crisis management was compared using a Wilcoxon test because of an extreme variable. Raw data from the pectoral heart rate monitor were recovered and analysed independently (none of the CardioMood® software analyses were used). RR outliers presumed to be due to artifact were graphically eliminated blindly from the randomization group and before any statistical analysis. The effect of intervention on SDNN and PLS over time was analysed using linear mixed-effects regressions.

## Results

### *Study population*

Between November 2017 and March 2018, 32 volunteer anaesthesia teams (64 subjects: 32 anaesthesia residents and 32 nurse anaesthetists) were enrolled and included in the analysis (16 pairs in each group, [Figure 2](#)). Group characteristics and baseline stress levels are provided in [Table 2](#). Participants were 31 yr old on average, 40% were female, and median [Q1 to Q3] baseline state-anxiety score was 38 [33 to 45] (20-80 scale).

### *Primary outcome*

[Team-based clinical performance scores of the intervention and control groups are displayed in Figure 3.](#) Mean (SD) overall performance score in the intervention group (positive communication behaviour during handover) was 44 (10) /100 points vs 35 (12) /100 points in the control group (P=0.04, +8.4 /100 points, 95%CI [0.4 to 16.4]). [The effects were homogenous over the three categories of tasks.](#)

### *Secondary outcomes*

[The median duration of crisis management was 7 \[6 to 8\] min and 8 \[6 to 8\] min in the intervention and control groups, respectively. A call for help was issued in a timely manner by 5/16 and 3/16](#)

teams in the intervention and control groups, respectively ( $P=0.6$ ). Psychological and physiological stress responses were lower in the intervention group, but no significant differences over time were shown in linear regression (PLS: -6 points, 95%CI [-13 to 2],  $P=0.13$ ; SDNN: +4 ms, 95%CI [-3 to 10],  $P=0.28$ ; **Figure 4**). Median PLS after handover was 44 [28 to 54] / 100 in the intervention group vs 50 [43 to 60] / 100 in the control group (-6 points, 95%CI [-13 to 1];  $P=0.09$ ). Median SDNN during crisis period was 58 [45 to 70] ms in the intervention group vs 52 [40 to 68] ms in the control group (+7 ms, 95%CI [-1 to 14],  $P=0.09$ ). Median state-anxiety at discharge was 28 [26 to 30] in the intervention group and 30 [24 to 34] in the control group ( $P=0.29$ ).

## Discussion

In this randomised controlled simulation trial, positive communication behaviour between healthcare professionals during handover improved subsequent team-based clinical team-based performance in a subsequent simulated anaesthesia crisis. **Although the category-specific performance scores were not significantly improved, all categories of expected tasks appear to have been affected homogeneously.**

Other studies found concordant results on the strong implications of social interactions within healthcare teams on the clinical performance. Positive communication within professionals can be learned, and may improve collegiality and teamwork.<sup>30</sup> Gratitude has also been shown to improve both technical and nontechnical clinical performance.<sup>31</sup> In contrast, other research teams focused on the **effect** of negative communication behaviours, which might be very frequent.<sup>32</sup> Incivility between healthcare professionals may harm clinical performance in critical anaesthesia situations.<sup>33</sup> **Similarly, patient or medical expert rudeness may have adverse consequences on both individual and team diagnostic and treatment performance.**<sup>34,35</sup>

In our study, positive communication behaviour during handover tended to decrease the overall psychological and physiological stress response (not statistically significant). Of note, handover causes an increase in stress response regardless of the communication behaviour. However the

subsequent crisis was associated with a decreased physiological stress response (SDNN increased) in the intervention group while it increased (SDNN decreased) in the control group. The overall absence of significant effect of the intervention in linear regression analysis may be due to a lack of power (our data showed high inter- and intra-individual variability in PLS and SDNN). Another hypothesis is that rather than leading to an absolute decrease in stress response, positive communication behaviour may lead to a shift from negative to positive stress, promoting a sense of self-confidence, security and social support among health professionals.<sup>15</sup>

Our study presents methodological strengths. The simulations were multi-professional, immersive and realistic. Residual anxiety at discharge was low, suggesting that debriefing was effective, and subjects' psychological safety was respected.<sup>36</sup> Clinical performance was blindly assessed by an independent assessor using video recordings and a scenario-specific scoring tool. **This tool encompasses both technical and nontechnical skills and provides a primary outcome that reflects clinical performance in a holistic manner.** Evidence for its validity arises from its specific content (previous development process involving independent subject-matter experts and pilot-test) and internal structure (interrater reliability previously confirmed after application in a sample of simulations). **Of note, inter-rater reliability was only moderate (ICC = 0.62) for the “crisis resource management and nontechnical skills” category, which is consistent with reference tools currently in use.**<sup>37</sup>

Our study suffers from several limitations. **It was a single-centre study involving a small number of participants, and the protocol did not include a qualitative analysis. Mechanisms of action of positive communication could therefore not be explored in detail. Multicentre randomised controlled trials would partly bridge the gap, but mixed methods studies including qualitative approaches would probably be the most appropriate.**<sup>38</sup> Second, a delicate issue was the communication behaviour adopted during handover for the control group: our objective was indeed to show the benefit of positive communication behaviour, and not the **drawback** of negative communication behaviour. The communication behaviour of the senior anaesthetist with the control group was therefore

intentionally close to real situations of fatigue or high stress, but without falling into caricature. Finally, this critical anaesthesia incident occurring just after handover was a somewhat **contrived** situation, and our findings cannot be extended to all possible critical situations in actual clinical practice.

### *Conclusions*

Positive communication behaviour between healthcare professionals during medical handover may improve clinical team performance during a subsequent critical care situation. Our findings call for further evaluations to confirm this **positive effect** and to study the underlying mechanisms. **Given its obvious safety, positive communication behaviour should be used in daily medical handover. Efforts and resources must be devoted to promoting its wide teaching and implementation, including by simulation as we and others have shown to be effective.**<sup>39</sup>

### **Author's contributions**

BB, J-NE: study design, participant recruitment, data acquisition, interpretation of results, writing up of the first draft of the manuscript, final approval of the version to be published and agreement to be accountable for all aspects of the work thereby ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

JPiot, RW: interpretation of results, critical revision of the manuscript for important intellectual content, final approval of the version to be published and agreement to be accountable for all aspects of the work thereby ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

P-MB: data acquisition, critical revision of the manuscript for important intellectual content, final approval of the version to be published and agreement to be accountable for all aspects of the work thereby ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

VL: participant recruitment, data acquisition, final approval of the version to be published and agreement to be accountable for all aspects of the work thereby ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

HT: statistical analyses, final approval of the version to be published and agreement to be accountable for all aspects of the work thereby ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

J-LB: study design, interpretation of results, writing up of the first draft of the manuscript, final approval of the version to be published and agreement to be accountable for all aspects of the work thereby ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

PA: study design, interpretation of results, critical revision of the manuscript for important intellectual content, final approval of the version to be published and agreement to be accountable for all aspects of the work thereby ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

JPicard: study design, randomization, data acquisition, interpretation of results, writing up of the first draft of the manuscript, final approval of the version to be published and agreement to be accountable for all aspects of the work thereby ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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## Declaration of interests

The authors declare that they have no conflicts of interest.

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## Tables

Table 1: Handover delivered by the senior anaesthetist to the participants

	Control group	Intervention group
	Control communication behaviour	Positive communication behaviour
<b>Duration of handover</b>	1 minute	
<b>Information provided</b>	7-yr-old boy with no medical history Planned circumcision Surgical safety checklist completed General anaesthesia induced with sevoflurane Airway controlled with a supraglottic device Bilateral pudendal block + 0.1µg kg <sup>-1</sup> sufentanil i.v. Surgeon about to make the incision	
<b>Nonverbal communication</b>		
Clothing	Coffee-stained and poorly fitting	Clean and tight
Facial expression	Stressed and tired face	Calm, relaxed and smiling face
Gaze orientation	Looking at the floor	Looking into the eyes
Posture	Closed, distant, crossed arms	Open, close, accompanying gestures
Voice	Fast, jerky, and sighing	Slow, regular, and grave
<b>Verbal communication</b>		
Phrases	Usual, with some negative turns	Avoidance of negative turns
Vocabulary <i>For example:</i>	Usual, with some negative words <i>“struggling boy”</i> <i>“complicated”</i> <i>“delay time”</i>	Positive words favoured <i>“cute dynamic little boy”</i> <i>“easily”, “comfort”</i> <i>“security”</i>
Additional comments <i>For example:</i>	Made of non-positive suggestions <i>“Oh, it's you...”</i> <i>“I hope everything goes well.”</i>	Made of positive suggestions <i>“Nice to see you!”</i> <i>“it's all right, you have my full trust.”</i>
<b>Reaction when the phone rings</b>	Picks up the phone, says he has no time to talk, then hang up.	Turns off the ringing phone and does not answer.

**Table 2.** Demographic and baseline information of participants.

	Control Group		Intervention Group	
	Resident (n=16)	Nurse (n=16)	Resident (n=16)	Nurse (n=16)
Age, yr	29 [27 to 30]	33 [30 to 38]	29 [27 to 30]	29 [29 to 34]
Experience, yr	4 [3 to 4]*	2 [1 to 4] <sup>§</sup>	4 [3 to 5]*	2 [1 to 3] <sup>§</sup>
Women	5 (31)	6 (37)	7 (44)	7 (44)
<b>Basal stress at d-15</b>				
STAI-T (20-80)	42 [35 to 48]	38 [33 to 46]	37 [33 to 44]	34 [31 to 44]
PSS (10-50)	37 [31 to 40]	32 [29 to 41]	34 [30 to 38]	27 [24 to 37]
<b>Stress status at arrival</b>				
STAI-S (20-80)	36 [31 to 43]	34 [30 to 39]	35 [31 to 41]	30 [25 to 33]
PLS (0-100 VAS)	50 [35 to 56]	35 [25 to 51]	36 [28 to 50]	46 [22 to 56]
SDNN, milliseconds	63 [41 to 78]	63 [53 to 77]	65 [58 to 77]	59 [44 to 65]
	Team (n=16)		Team (n=16)	
Junior teams <sup>#</sup>	7 (44)		6 (38)	
Previous work together	4 (25)		5 (31)	
Mixed team (Female-Male)	7 (44)		8 (50)	

Data are median [Q1 to Q3] or n (%). \*: since the beginning of residency. <sup>§</sup>: since the beginning of the nurse anaesthetist school. d-15, 15 days before intervention; STAI-T, State Trait Anxiety Inventory - Trait anxiety; PSS, Perceived Stress Scale; STAI-S, State Trait Anxiety Inventory - State anxiety; PLS, Perceived level of stress VAS, Visual Analog Scale; SDNN, Standard Deviation Normal to Normal. <sup>#</sup>: Junior teams: a year 2-3 resident and a 2<sup>nd</sup>-year student nurse anaesthetist (while experienced teams: a year 4-5 resident and a certified nurse anaesthetist)

## Figure legends

**Figure 1.** Timeline: Conduct of the study and distribution of the measurements.

*d-15, 15 days before intervention; STAI-S, State Trait Anxiety Inventory - State anxiety; VAS, Visual Analog Scale; SDNN, Standard Deviation Normal to Normal; STAI-T, State Trait Anxiety Inventory - Trait anxiety; PSS, Perceived Stress Scale.*

**Figure 2.** Flow Diagram.

*Based on CONSORT Guidelines.*

**Figure 3.** Overall (a.) and category-specific (b.) team-based clinical performance scores.

*Box plots show, bottom to top, minimum, 25<sup>th</sup> percentile (Q1), median, 75<sup>th</sup> percentile (Q3) and maximum values. Outliers (shown as points) are defined by values below  $Q1-1.5*[Q1-Q3]$  or above  $Q3+1.5*[Q1-Q3]$ .*

**Figure 4.** Psychological (a) and physiological (b) stress response over time.

*Data presented in difference from basal values, SDNN in milliseconds, VAS on a scale of 100 points. Each point is represented with 25<sup>th</sup> percentile, Median, and 75<sup>th</sup> percentile. VAS, Visual Analogue Scale; SDNN, Standard Deviation Normal to Normal.*



## Enrollment

Residents contacted by mail (n=35)

Nurses contacted by mail (n=35)

32 first responses

32 first responses

Composition of 32 teams with 1 resident & 1 nurse  
based on order of response and experience (n=32 teams)

Randomized (n=32 teams)

## Allocation

Allocated to intervention group (n=16)

Allocated to control group (n=16)

## Intervention

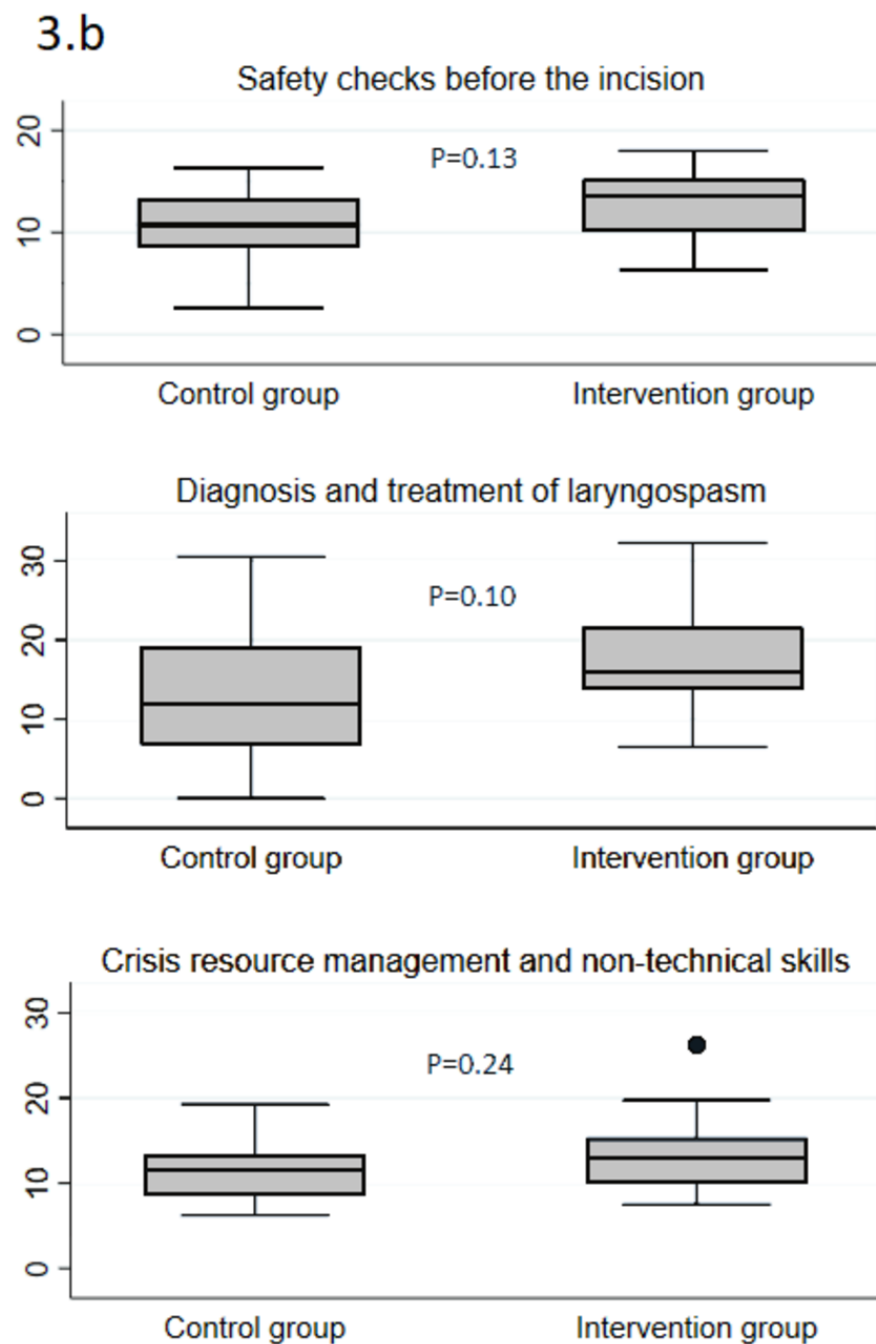
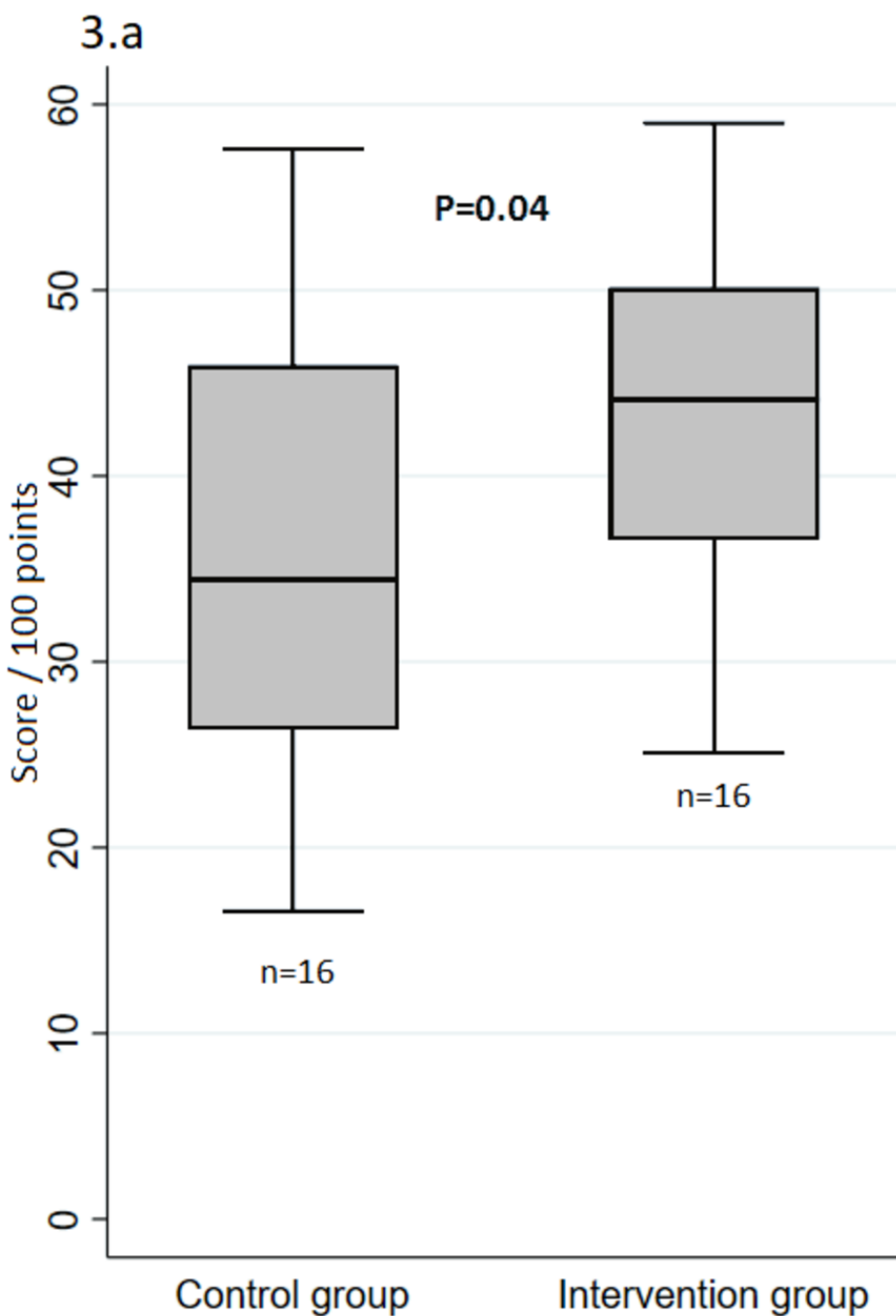
Received allocated intervention (n=16)

Received allocated intervention (n=16)

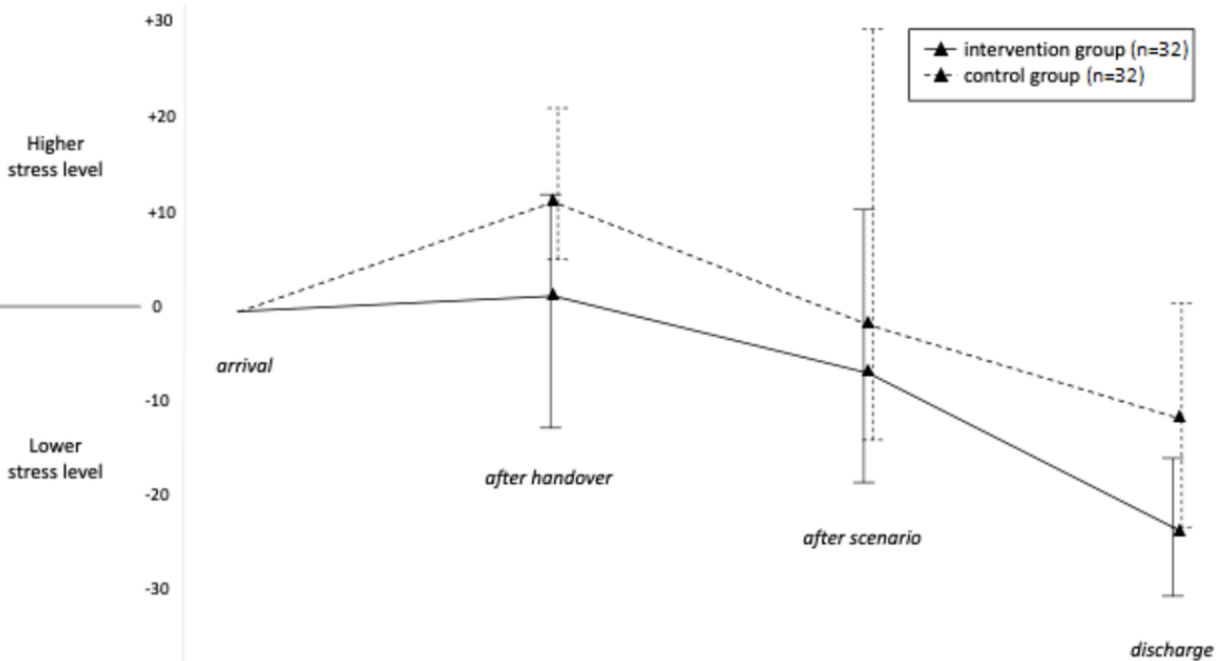
## Analysis

Analysed (n=16)

Analysed (n=16)



4.a Variation of perceived level of stress, 0-100 VAS



4.b SDNN variation, ms

