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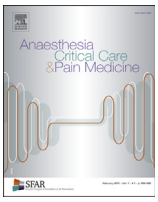

The effect of playing video games on fiberoptic intubation skills

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ABSTRACT

Introduction:The effect on hand-eye coordination and visuospatial skills made videogames popular for training in laparoscopic surgery. Although similar effects may be true for fiberoptic intubation (FOI), it hasn't been studied before. The aim of this study was to investigate the effect of playing videogames with gamepad on FOI skills.

Methods: After obtaining ethical approval and informed consent, 36 anaesthesia residents with no experience on fiberoptic intubation were divided into two groups. Group C (n = 18) consisted of the residents without any videogame experience with gamepad. Group PS (n = 18) played a videogame 30 minutes/day for five days. All residents performed their first nasal FOI on a patient undergoing orthognathic surgery with no known difficult intubation under general anaesthesia under supervision of an experienced anaesthesiologist. Intubation time, success rate, pre- and post-intubation SpO2 and etCO2 values were recorded.

Results:Intubation time was shorter (p = 0,017) and success rate at the first attempt was higher in Group PS (p = 0,045) compared to Group C. We performed multivariate linear regression analysis to investigate which independent variables (gender of residents, experience in anaesthesiology, dominant hand, study group and previous history of videogame experience) affected our dependent variable intubation time. Backward analysis revealed previous videogame playing history (previous players vs. non-players) was the only significant predictor of intubation time (p = 0.010).

Conclusion:Although we cannot reliably suggest using videogames as an educational tool for FOI, the results of our study showed that videogame playing history may provide an improvement in FOI time of novices in actual operating-theatre environment.

Introduction

The positive effects of videogames on training laparoscopic skills were suggested in many studies in recent years. Videogame playing was shown to improve surgical performance on simulators both in terms of time and smoothness of the skills [1]. The underlying principle of studying videogames is their beneficial effect on improving visuospatial skills, eye-hand coordination, depth perception, ambidexterity and problem-solving skills. Although their utility is not yet widely accepted for this purpose, videogames offer the potential for a relatively cheaper, portable, effective and motivating way for training compared to simulation systems [2].

Flexible fiberoptic intubation (FOI) is an advanced airway management skill that requires intense training to acquire sufficient competency [3]. Junior anaesthesiologists reported that they believe their level of competence in FOI was insufficient and lack of training was found to be one of the main reasons to avoid the use of FOI in difficult airway management situations [4,5].

We hypothesised that the positive effects of videogames on laparoscopic skills might also be similar for flexible fiberoptic bronchoscopy. However, no previous study investigated these effects on FOI skills. The aim of the current study was to investigate the effect of playing videogame with gamepad on FOI skills of anaesthesiology residents with no previous experience of fiberoptic intubation.

Materials and Methods

Following local ethical committee approval (protocol number: KA-16034, approval date: 06.05.2016, chair: Prof. Dr. F. Alev Turker)

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and written informed consent from both the residents and the patients, the study was conducted at the operating theatre of Hacettepe University, Faculty of Medicine, Ankara, Turkey between 01.06.2016 and 01.09.2017.

Participants

The Residents

Thirty-six first-year anaesthesiology residents with no experience on FOI were enrolled in the study from the same institution. None of the residents had prior experience on FOI either in a manikin. Exclusion criteria were the experience in anaesthesiology less than one month and unwillingness of the resident.

All residents (n = 36) were questioned about their previous experience of videogame playing before allocating them to study groups (Group C (Control Group) and Group PS (PlayStation Group)). Sixteen of residents were found to have previous videogame history at least once in their life, so they were compulsorily enrolled to Group PS in a non-randomised way to differentiate between videogame players and non-players. The rest 20 residents were assigned to the groups (18 in Group C and 2 in Group PS) by computer-based randomisation. Consequently, the residents (n = 36) were allocated to two groups in equal numbers. Group C consisted of residents without any videogame experience with gamepad (n = 18) and Group PS consisted of 16 residents with previous videogame experience and 2 residents without any videogame experience (n = 18).

The Patients

Patients who were scheduled to undergo elective orthognatic surgery requiring nasal intubation were included. Exclusion criteria were known or anticipated difficult intubation and/or mask ventilation, known nasal abnormalities such as septal deviations or spurs, previous nasal surgery, obesity (body mass index $\geq$ 30 kg/m^2), obstructive sleep apnoea syndrome, age <18 year-old or >50 year-old, any respiratory or cardiopulmonary diseases, history of coagulation abnormalities, indication for rapid sequence induction and unwillingness of the patient. Additionally, any patients who were not indicated to be nasally intubated due to surgical reasons were not included in the study. Patients were allocated to one of the groups by computer-based randomisation and all patients were blinded to the study groups.

Study Protocol

The residents in Group PS (n = 18) played a videogame with PlayStation®4 (Sony Corporation, Tokyo, Japan) for 30 minutes a day for five days in a specifically stated comfortable room in the hospital under supervision of one of the authors (AAY) to accompany them. The residents in Group C (n = 18) did not play any videogames during the study period. All residents watched a standard demonstrative 10-minute video of FOI one hour before their performance. The basic parts of the fiberoptic bronchoscope and tips for usage were described and a real performance of nasal FOI on a patient with normal anatomy was shown by one of the authors (AAY) in this standard video. Then all residents were given 20 minutes to examine the bronchoscope and try basic manoeuvres hands on. After that, all residents performed a nasal FOI of a patient undergoing orthognatic surgery without known or anticipated difficult airway. All intubations were performed under general anaesthesia under the supervision of the same senior anaesthesiologist (OC) who was blinded to the study group. The senior anaesthesiologist was allowed to offer verbal cues in times of struggle by the resident up to three times during an intubation attempt. Performing nasotracheal intubation by using fiberoptic bronchoscope in patients undergoing orthognatic surgery is the standard procedure in our hospital because this technique has been shown to be less traumatic than blind nasotracheal insertion of the endotracheal tube in sleeping patients [6]. The performance of nasotracheal FOI under general anaesthesia in patients who require nasal approach indicated by the type of surgery in oral cavity gives us the opportunity of better patient comfort provided that there is no known or anticipated difficult airway.

On arrival to the operating room, patients were monitored by electrocardiogram, non-invasive blood pressure and pulse oximeter. A standard 20 gauge IV cannula was inserted and all patients were pre-oxygenated in 30° upright position with Airvo2 high-flow humidified nasal oxygen therapy (70 lt/min) (Fisher & Paykel Healthcare, Auckland, New Zealand) for 5 minutes. Anaesthesia induction was performed with IV 2.5 mg/kg propofol, 1-2 μg/kg fentanyl and 0.6 mg/kg rocuronium bromide. Following induction and confirming effective facemask ventilation, all patients' nostrils were dilated with the same type nasal dilators (lubricated) starting from number 6 up to number 7.5 or 8 till there was no resistance against the passage of the dilator. The intubation attempts were started after dilation. Airvo2 was maintained to apply oxygen continuously throughout all procedures to secure apnoea period and was only discontinued after successful intubation.

An intubation attempt by a resident was defined as the time between insertion of fiberoptic bronchoscope through the nostril and the first measurement of $etCO_2$ or up to 180 sec in case of failed intubation. In case of >180 sec or SpO_2<90%, first attempt of intubation was terminated and mask ventilation was started immediately. If the resident failed in the first attempt of intubation, then a second attempt was initiated after three minutes of mask ventilation. In case of >180 sec or SpO_2<90%, second attempt was also terminated and the intubation was performed by the senior anaesthesiologist (OC). During all intubation attempts, jaw-thrust manoeuvre was applied to all patients with the same experienced anaesthesia nurse who was also blinded to the study groups.

The primary outcome of the study was to compare the intubation times between groups. Intubation time was defined as the time from insertion of fiberoptic bronchoscope through the nostril to the first measurement of $etCO_2$. Secondary outcomes were success rate of intubation, pre- and post-intubation SpO_2 and $etCO_2$ values and related complications. All patients were questioned for postoperative complications 30 minutes after recovery of anaesthesia in the post-anaesthesia care unit and six hours after recovery in the ward. Patients were asked to rate their sore throat (1: no, 2: mild, 3: moderate, 4: severe). Nasal bleeding (1: no, 2: mild, 3: moderate, 4: severe) was assessed by the surgeons who were blinded to the study groups.

Demographical (age, sex, weight, height, BMI) data, clinical characteristics and pre- and post-intubation vital parameters of all patients and the age, sex, dominant hand (right/left), experience in the field of anaesthesiology (months) and videogame playing history (previous players/non-players) of the residents were also recorded.

The videogame

The videogame played by Group PS was a standard game, which can be easily found in the markets, 'Call of Duty 4 Modern Warfare' (ActiVision, California, United States). This game was chosen because throughout the game the player follows his commander by going up and down, climbing stairs and turning to both sides frequently. In order to provide these movements of gamepad, the player uses his/her thumb of dominant hand similar to an operator manipulating the FOB heading towards the trachea from nasal

passage. Also the player needs to target the enemy before shooting and that movement is also similar to targeting the centre of the airway passage while moving downwards.

Statistical analysis

Data analysis was performed by using IBM SPSS Statistics version 21.0 software (IBM Corporation, Armonk, NY, USA). While, categorical data were shown as number of cases and percentages, descriptive statistics for continuous variables were expressed as mean ± SD or median (min-max), where applicable. The mean differences between the groups were compared by independent samples t-test and Mann-Whitney U test, where applicable. A backward multivariate linear regression analysis was performed to investigate which independent variables (gender of residents, experience in the field of anaesthesiology, dominant hand, study group and history of PlayStation experience) affect our dependent variable, intubation time. A p value less than 0.05 was considered statistically significant.

Sample Size Estimation

Sample size estimation was performed by using G*Power (Franz Faul, Universität Kiel, Kiel, Germany) version 3.0.10. The primary aim of this study was to compare the difference in intubation times between Control Group and PS Group. According to studies investigating FOI skills that mentioned significant time differences of 30-35 sec between simulation/manikin study groups and control groups [7,8,9]; we hypothesised that a difference of 30 sec could be accepted as clinically significant. A total sample size of 34 (17 in each group) was calculated to achieve 80% power with an α error of 0.05 and an acceptable Cohen's d effect size of 1,02 in terms of physiology and education [10,11]. We decided to recruit 36 patients to allow for dropouts.

Results

Thirty-six anaesthesiology residents in their first year without any FOI experience were enrolled, 18 in Group C and 18 in Group PS.

Two groups were comparable in terms of demographic data and pre-intubation vital parameters of patients, which could affect the level of intubation difficulty and anaesthesia depth (Table I).

Intubation times were significantly shorter in Group PS (n = 18) compared to Group C (n = 15 for this data, three residents could not perform a successful intubation in Group C) (90.0 ± 45.5 sec and 127.6 ± 39.5 sec respectively, p = 0.017). All residents in Group PS performed a successful FOI at first attempt, however 5 residents failed to intubate patients' trachea at first attempt in Group C. Only two of these five residents could perform a successful intubation at the second attempt. Although total success rates were similar between two groups (p = 0.074), the difference in first attempt success rate was found statistically significant (p = 0.045) in favour of Group PS.

Pre-intubation $etCO_2$ measures were similar, however we found a statistically significant elevation in $etCO_2$ values of Group C at the end of fiberoptic intubation (37.5 ± 4.7 in Group C, 34.0 ± 4.4 in Group PS, p = 0.027). This difference was thought to be due to higher apnoeic period however all the measures in both groups were within normal range. Two groups were also similar according to SpO_2 measured just after the intubation and the lowest SpO_2 measured all through the process (median SpO_2: 99 (98-100) in Group C and 99 (96-100) in Group PS, p = 0,481). None of the patients experienced a SpO_2 below 96%. So the difference in post-intubation $etCO_2$ does not seem to be clinically significant.

There were no differences between two groups according to postoperative sore throat, nose bleeding and other possible complications both in post-anaesthesia care unit and in the ward. Other complications expressed by the patients were postnasal drip in two patients and dysphagia in one patient in Group C and dry throat in one patient in Group PS.

Apart from sex, residents in two groups were equally distributed according to age, experience in the field of anaesthesiology (months at work) and dominant hand (right/left) (Table II). None of the residents had history of previous videogame playing in Group C. All residents in Group PS had a history of previous videogame experience except two. We performed multivariate linear regression analysis to investigate which independent variables (gender of residents, experience in the field of anaesthesiology, dominant hand, study group and history of videogame experience) affect our dependent variable, intubation time. Backward analysis revealed previous videogame playing history (previous players vs. non-players) was the only statistically significant predictor of intubation time (p = 0.010).

Discussion

In our study, we found that FOI times were significantly shorter and first attempt success rate of FOI was higher in Group PS compared to Group C. Apart from these results, previous videogame playing history was the only statistically significant predictor of intubation time according to multivariate linear regression analysis in this study. These results showed that playing videogames with gamepad may have a positive effect on fiberoptic skills performed by novices in actual operating-theatre environment.

The positive cognitive effects in game players are usually attributed to improved eye-hand coordination, having faster reaction times, enhanced decision making, executive functioning and attention, visual anticipation and increased capacity to switch between tasks [1,12,13]. Despite the limited data in the area of medical training, the neurophysiological evidence of cognitive improvement with videogame playing is increasing [13,14,15,16]. There are reports showing neuroplastic changes in both grey and white matter even only after 2 hours of videogame playing [15]. A study using structural MRI showed that the volume of dorsolateral prefrontal cortex, which has a key role in working memory and executive functions, was correlated with improvements in game performance in older adults following 20 hours of action videogame training [17]. Wu et al. found that even only 10 hour of training with action videogames was sufficient for novices to achieve improvement in visual attention [18]. On the other hand, there are controversial results that some studies in the videogame literature have failed to prove any long-term enhancement [13]. The relationship between cognitive impairment and the intensity or length of videogame playing is still controversial. Which effects occur after small amounts of training and which require extensive training is not known actually. However, it is not unexpected that today's videogame medium delivering a multisensory stimulation and requiring the player to follow challenging tasks in a complex and dynamic environment might possibly lead to cognitive changes. This potential area has been recently taken into consideration for purposes beyond entertainment such as mental health and education [16].

Videogames has gained popularity as being cheaper and cost-effective alternative to simulators for training laparoscopic skills in recent years. Beyond the broad range of cognitive enhancement discussed above, being more adapted to the translation of a three-dimensional area into a two-dimensional screen, ambidexterity and better depth perception are among other possible positive

effects of videogame playing in the field of surgical training [1,12]. Several studies showed improvement in laparoscopic skills, reduction in error rates on a specific laparoscopic task and/or time needed for completing the tasks after videogame playing even compared with traditional simulator systems [2,11,19,20,21]. Although further detailed studies are required to accept videogames as a training method for laparoscopic skills, videogame industry may be used as a fun, motivative and cost-effective way to improve surgical skills in future.

Fiberoptic bronchoscopy skills can be considered similar to laparoscopic skills in many ways including the need for improved eye-hand coordination and the translation of the real three-dimensional airway anatomy to a two-dimensional screen image. The flexible FOI technique requires intense training particularly for learning how to manipulate the scope easily and effectively, however, these instruments can be easily damaged and are expensive [4,22]. Simulators and manikins are reasonable methods to be recommended for practice but they also have some drawbacks. Simulators can be expensive and hard to acquire for some institutions. Manikins are static and cannot always resemble a real patient due to lack of secretions and blood. Therefore, we hypothesised that videogames may be useful tools to study FOI as they seem to be in laparoscopic skills. This study was the first to investigate the effect of playing videogames on FOI skills.

Giglioli et al [3] evaluated the use of 'Virtual Fiberoptic Intubation' CD-Rom with which the trainees drove the bronchoscope through the airway by just using mouse and keyboard. In that study, practicing the cognitive component of FOI skill solely improved the initial performances of trainees. In contrast, we studied the effect of playing videogames with gamepad, which can be considered as a way to practice the psychomotor task of manipulating the bronchoscope due to its similarity. The practice of the cognitive component was standardised as all the residents watched the same teaching video in our study, and the performance of novices were also improved. Gaining automaticity in manipulating the bronchoschope might have an improved effect on the final multicomponent task due to part task training theory [3] although the game did not have a medical component regarding airway anatomy.

The lack of a dedicated game for training is the main limitation to evaluate the effects of videogames on basic laparoscopic skills as well as fiberoptic bronchoscopy skills. Nobody knows which is the best game in this perspective and to our knowledge there is no institutional routine practice with such a tool. Many studies were performed with standard games that can be found in the markets, however some authors are working on designing custom-made games, which target some basic laparoscopic skills specifically [12,23].

The study has some limitations regarding the design. First, the residents with previous videogame history were enrolled to Group PS in a non-randomised way to differentiate between videogame players and non-players, so the study design was not completely randomised controlled. And we could not ignore a possible positive and motivational effect and increase in self-confidence of the residents in Group PS. It could be considered to include only residents with no significant past history in video gaming, however it was nearly impossible to achieve a statistically sufficient population without videogame experience with today's generation. Secondly, the groups were not similar according to gender of the residents with a female predominance in Group C. Male predominance in action videogame players and female predominance in non-players were also seen in many other studies in the literature [13]. A study investigating the effect of gender in videogame training found no difference in enhancement of attention performance between females and males [24]. Also, multivariate linear regression analysis in our study showed that gender did not have any impact on intubation time. Thirdly, we could not compare the effect of playing videogames with a simulator because we do not have a simulation programme in our institution due to its expenses. Lastly, we evaluated the effect of playing videogames on FOI skills without comparing the effect of different PlayStation playing periods. Although the intubation time was shorter and first attempt success rate of FOI was higher in Group PS, previous videogame playing history was the only statistically significant predictor of intubation time in the current study. With this data, we cannot clarify whether the difference is actually due to the five-day studying period or the previous videogame experience. Probably, repeated training sessions for multiple weeks could be more effective. But we cannot make a conclusion regarding the optimal period of training required with this current data and the limited literature [15]. However, we believe that the results of our study may prove useful, as being the first on the subject, to lead future studies addressing the effects of videogame playing on fiberoptic bronchoscopy skills.

Post-game assessments for laparoscopic skills were usually performed on simulators or interventions on laboratory animals like anesthetised pigs [1]. One of the strengths of our study was that all the assessments were on real patients in an operating-theatre environment under the supervision of an experienced anaesthesiologist. We could be able to investigate the real situation with secretions and blood of the patient and the tongue of the paralysed and anesthetised patient occluding the airway. Although training the novices first on manikins or simulators is certainly more ethical; as we do not have simulators or manikins available for nasal intubation in our institution, the residents perform their first fiberoptic tracheal intubation on real patients without known/anticipated difficult airway under the supervision of a senior anaesthesiologist in our routine practice also.

As a conclusion; although we cannot reliably suggest using videogames as an educational tool for FOI, the results of our study showed that videogame playing history may provide an improvement in FOI time of novices in actual operating-theatre environment.

Author Contributions: Conceived and designed the study: AAY, OC. Conducted the study: AAY, BA, FU, AM, MC. Supervised the data collection: OC, IV. Analysed the data: AAY, AM, BA. Helped statistical analysis: OC, FU. Contributed to writing of the manuscript: AAY, AM, BA, MC. Revisions of the manuscript: FU, OC, IV. All authors reviewed and approved the final form of the manuscript.

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Ethical Statements

This single centered study was approved by institutional ethical committee with protocol number: KA-16034. (Approval date: 06.05.2016, chair: Prof. Dr. F. Alev Turker).

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