JOURNAL OF CLINICAL MEDICINE OF KAZAKHSTAN (E-ISSN 2313-1519)
Original Article DOI: https://doi.org/10.23950/jcmk/13765

Conventional videolaryngoscope versus 3D printed videolaryngoscope

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Received: 2023-07-08.
Accepted: 2023-10-03

J Clin Med Kaz 2023; 20(5):60-64

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Abstract

Background and objectives: In patients with Covid-19, using a video laryngoscope as an alternative to direct laryngoscopy is recommended to protect the intubator from infection and reduce intubation failures due to personal protective equipment. The cost of video laryngoscopes limits their availability in all healthcare institutions. The present study aimed to compare the efficacy and safety of 3D printed video laryngoscope and conventional video laryngoscope on intubation.

Material and methods: 30 ASA I-II patients who were not considered to have a difficult airway were included in the study after obtaining the ethics committee approval from Adnan Menderes University Clinical Research Ethics Committee. Patients were randomly divided into two groups, group 1 and group 2. After the induction of anesthesia under standard monitoring, the Cormack Lehane score was recorded by direct laryngoscopy in all patients. Patients in group 1 were intubated with a 3D-printed video laryngoscope. In contrast, patients in group 2 were intubated with a conventional video laryngoscope (STORZ C-mac videolaryngoscope). Intubation time, number of attempts, and hemodynamic values of patients with early postoperative complications were recorded. The data were recorded and statistically evaluated.

Results: There were no significant differences between the groups regarding demographic data, BMI, and hemodynamic data. The Cormack Lehane score was calculated as 1.6±0.51 in group 1 and 1.4±0.51 in group 2 (p=0.38). Intubation times of the groups were 32.6±18 s and 27.06±11.37 s, respectively (p=0.4). The number of intubation attempts was 1.2±0.63 in group 1 and 1±0.01 in group 2 (p=0.31). The image quality of the camera by the intubator, intubation conditions, and intubation satisfaction was similar in the two groups.

Conclusion: Comparing a 3D-printed videolaryngoscope with a conventional videolaryngoscope, no differences were observed in intubation times, number of intubation attempts, hemodynamic changes, and early postoperative complications. Intubation satisfaction values by the practitioner were found to be similar. It was concluded that the 3D-printed videolaryngoscope, which is cost-effective and easy to access, can be used instead of conventional videolaryngoscope in patients with a normal airway.

Key words: videolaryngoscope

Introduction

Endotracheal intubation is an aerosol-generating medical procedure that carries a high risk of pathogen transmission to the practitioner [1]. Anesthesiologists and intensivists are particularly at risk for infection transmissions [2]. Approximately 10% of healthcare workers who perform endotracheal intubation on patients with suspected or confirmed Covid-19 are reported to be infected with Covid-19 [3]. In patients infected with Covid-19, the use of video laryngoscopes instead of direct laryngoscopy is recommended to protect the intubator from infection and to reduce intubation failure due to personal protective equipment worn to prevent exposure to infection [4]. However, the cost of video laryngoscopes limits their availability in all health institutions. In clinics where the number of video laryngoscopes is inadequate, waiting for equipment for many simultaneous operations prevents effective use of the operating room. Also, this leads to disruption in the cleaning and disinfection steps of the video laryngoscope. Therefore, it was thought that 3D printed video laryngoscope, which is more readily available to clinics and has a lower cost, can be used. The

present study aimed to compare the efficacy and safety of 3D printed video laryngoscope and conventional video laryngoscope on intubation.

Material and methods

The present study was carried out prospectively with the approval of the Adnan Menderes University ethics committee (197/2020). A 3D printed videolaryngoscope was created by designing the handle from polylactic acid raw material, placing a wi-fi 1080P HD camera, and passing cytotoxicity, sensitization, irritation tests, and obtaining approval (Kırıkkale University Scientific and Technological Research Application and Research Center report number: 2022/000022-IVV-IRT-207). A total of 30 patients aged 18-65 years, ASA I-II, and undergoing elective surgery under general anesthesia were included in the study. Patients with difficult intubation (mallampathy III-IV, head-neck mobility limitation, kyphoscoliosis, undergoing or planned oral/neck surgery, prognathism and incisor spacing less than 2 cm), delayed gastric emptying (gastrointestinal malignancy, ileus), and gastroesophageal reflux patients and pregnant women were excluded. Intubations performed in three and/or more attempts were considered unsuccessful and were excluded from the study. Patients were informed preoperatively, and verbal and written informed consent was obtained. Demographic information (age, sex, height, weight), mallampathy scores, and the reason for anticipating difficult intubation, if any, were recorded. All patients included in the study were randomized, and the patients were divided into two groups. Group 1 was the 3D-printed video laryngoscope group, and Group 2 was the conventional video laryngoscope intubation. The patients were then taken to the operating room for the surgical procedure. Standard monitoring (heart rate, oxygen saturation, and non-invasive blood pressure) was performed. Anesthesia induction of all patients included in the study was achieved with intravenous (iv) lidocaine 1 mg/kg, propofol 2-3 mg/kg, and iv fentanyl 1µcg/kg. After ventilation with an appropriate face mask, iv-rocuronium 0.6 mg/kg was administered for neuromuscular blockade. After adequate mask ventilation, the glottic appearance of the patients in both groups was evaluated by direct laryngoscopy, and Cormack-Lehane (C&L) scores were recorded. The patients in group 1 were then intubated with a 3D-printed video laryngoscope. The patients in group 2 were intubated with pre-styled intubation tubes using a conventional video laryngoscope (STORZ C-MAC® videolaryngoscope). Intubation of patients in both groups was performed by anesthesia assistants with at least four (4) years of intubation experience and similar video laryngoscope experience. Correct placement of the endotracheal tube was confirmed by chest elevation and capnography. Patients were mechanically ventilated. The duration of intubation (from when the laryngoscope entered the oral cavity until the appearance of the end-tidal carbon dioxide wave), the number of intubation attempts, and complications (laceration, tooth damage, bleeding) were recorded. The camera's image quality, intubation conditions, and intubation satisfaction were evaluated by the person performing endotracheal intubation with a minimum score of 1 and a maximum score of 4. The recorded parameters are as follows; heart rate (HR), systolic arterial pressure (SAP), diastolic arterial pressure (DAP), mean arterial pressure (MAP), peripheral oxygen saturation (SpO_2), before induction (T0), immediately after induction (T1), immediately after intubation (T2) and at 1-minute intervals for 5 minutes (T3, T4, T5, T6, T7), while end-tidal carbon dioxide (ETCO2) immediately after intubation and at 1, 2, 3, 4, and 5 minutes after intubation. Patients were also examined at the sixth hour to evaluate for postoperative complications. The data were recorded and statistically analyzed.

Statistical analysis

The SPSS 25 for data evaluation (IBM Corp. Release 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) statistical package program was utilized for the statistical evaluations. The variables are expressed using mean±standard deviation, percentile, and frequency values. The Kolmogorov-Smirnov test was performed to evaluate the homogeneity of the data. The Mann-Whitney U and chi-square test were used to analyze the data. The level of significance was set as $P<0.05$.

Results

The data of a total of 30 patients in group 1 and group 2 were analyzed. All 15 patients in group 1 were female; the mean age was 37.52±10.52 years. In group 2, 12 patients were female; the mean age was 34.6±13.83 years. The patients' body mass index was calculated as 23.97±5.07 kg/m2 in group 1 and 23.89±4.13 kg/m2 in group 2. No significant differences were found between the groups in terms of age and body mass index ($p>0.05$). There were no patients with a prediction of difficult intubation in both group. Intubation time was calculated as 32.6±18 s and 27.06±11.37 s in group 1 and group 2, respectively ($p=0.4$). The number of attempts was calculated as 1.2±0.63 in group 1 and 1±0.01 in group 2 ($p=0.31$). The Cormack-Lehane score was calculated as 1.6±0.51 and 1.4±0.51 in groups 1 and 2, respectively ($p=0.38$) (Table 1).

Table 1 Cormack- Lehane score and intubation result

	Group 1	Group 2	P
Cormack-Lehane Score	1.6±0,51	1.4±0.51	0.38
Intubation Time (seconds)	32.6±18	27.06±11.37	0.4
Number of Intubation Trials	1.2±0.63	1±0.01	0.31

Data are presented as mean±standard deviation

The patients' pulse rates before the anesthesia induction (T0) were 80.2±10.46 in group 1 and 85.73±17.78 in group 2. There were no significant differences between the groups according to pulse rate values before the induction of anesthesia ($p=0.72$). Instantaneous pulse rate values after anesthesia (T1) induction were 82.26±15.48 in group 1 and 91.4±18.41 in group 2 ($p=0.96$). After intubation (T2), the instantaneous pulse rate was 90.4±11.45 in group 1 and 94.2±18.87 in group 2. The groups had no significant differences in the instantaneous pulse rate values after intubation ($p=0.9$). Pulse rates measured at 1-minute-intervals for 5 minute after intubation (T3, T4, T5, T6, T7) were 91.13±13.10, 92.26±17.33, 92.06±17.70, 88.13±16.20, 86.26±17.04 in group 1 and 92.93±14.61, 95.13±14.09, 92.93±13.07, 92.66±9.04, 93.06±11.87 in group 2, respectively. Both groups had similar pulse rates at the 1st, 2nd, 3rd, 4th, and 5th minute after the intubation ($p>0.05$) (Table 2). The systolic blood pressure before the induction of anesthesia (T0) was 124.33±12.49 mmHg in group 1 and 125.53±22.41 mmHg in group 2 ($p=0.96$).

Table 2 Heart rate data

	Group 1	Group 2	P
T_0	80.2±10.46	85.73±17.78	0.72
T_1	82.26±15.48	91.4±18.41	0.96
T_2	90.4±11.45	94.2±18.87	0.9
T_3	91.13±13.10	92.93±14.61	0.9
T_4	92.26±17.33	95.13±14.09	0.77
T_5	92.06±17.70	92.93±13.07	0.8
T_6	88.13±16.20	92.66±9.04	0.44
T_7	86.26±17.04	93.06±11.87	0.11

Data are presented as mean±standard deviation

After the induction of anesthesia (T1), systolic blood pressure was 120.86±22.98 and 122.73±21.95 mmHg in groups 1 and 2, respectively (p=0.85). Systolic blood pressure measured immediately after intubation (T2) was 125.13±25.51 mmHg in group 1 and 117.06±13.95 mmHg in group 2. The systolic blood pressures measured at 1-minute-intervals for 5 minutes after intubation (T3, T4, T5, T6, T7) were 110.93±21.55, 104.8±23. 77, 111.93±28.83, 106.46±24.74, 103.2±21.19 mmHg in group 1 and 113.06±20.85, 113.28±42.03, 108.5±31.88, 108.71±18.46 and 103.78±14.59 mmHg in group 2, respectively. The groups had no significant differences according to the systolic blood pressures at the 1st, 2nd, 3rd, 4th, and 5th minute after the intubation (p>0.05) (Table 3).

Table 3 Systolic blood pressure result

	Group 1	Group 2	P
T_0	124.33±12.49	125.53±22.41	0.96
T_1	120.86±22.98	122.73±21.95	0.85
T_2	125.13±25.51	117.06±13,95	0.34
T_3	110.93±21.55	113.06±20.85	0.78
T_4	104.8±23.77	113.28±42.03	0.89
T_5	111,93±28.83	108.5±31.88	0.23
T_6	106.46±24.74	108.71±18.46	0.48
T_7	103.2±21.19	103.78±14.59	0.63

Data are presented as mean±standard deviation.

The diastolic blood pressure of the patients in group 1 before the induction of anesthesia (T0) was 72.73±8.81 mmHg and 70.4±14.88 mmHg in group 2 (p=0.95). After the induction of anesthesia (T1), diastolic blood pressure was 75.2±16.54 and 73.4±14.06 mmHg in groups 1 and 2, respectively (p=0.81). Diastolic blood pressure measured immediately after the intubation (T2) was 77.26±16.64 mm Hg in group 1 and 70.53±12.47 mm Hg in group 2 (p=0.23). Diastolic blood pressures at 1-minute-intervals for 5 minutes after the intubation (T3, T4, T5, T6, T7) were 69.46±13.75, 66.0±16.15, 67. 73±13.18, 64.86±16.79 and 62.93±17.19 mmHg in group 1 and 66.13±10.27, 66.35±19.21, 62.64±13.06, 64.78±11.11 and 60.64±7.67 mmHg in group 2, respectively. No significant differences were found in both groups' diastolic blood pressure values at the 1st, 2nd, 3rd, 4th, and 5th minutes after intubation (p>0.05) (Table 4). The mean arterial blood pressure before the induction of anesthesia (T0) was 93.53±10.23 mmHg in group 1 and 88.66±19.54 mmHg in group 2 (p=0.88). Mean arterial blood pressure after the induction of anesthesia (T1) was 91.46±15.17 and 92.8±16.33 mmHg in groups 1 and 2, respectively (p=0.74). Mean arterial blood pressure measured immediately after the intubation (T2) was 96.53±19.23 mmHg in group 1 and 89.13±14.66 mmHg in group 2 (p=0.31). Mean arterial pressures were calculated as 85.80±16.69, 81.26±18.39, 86.93±21.66, 81.40±18.65 and 79.53±16.80 mmHg in group 1 and 86.66±15.73, 85.42±24.16, 80.78±17.52, 83.71±11.64 and 79±9.58 mmHg in group 2 at 1-minute-intervals for 5 minutes (T3, T4, T5, T6, T7) after the intubation, respectively.

Table 4 Diastolic blood pressure result

	Group 1	Group 2	P
T_0	72.73±8.81	70.4±14.88	0.95
T_1	75.2±16.54	73.4±14.06	0.81
T_2	77.26±16.64	70.53±12.47	0.23
T_3	69.46±13.75	66.13±10.27	0.67
T_4	66.0±16.15	66.35±19.21	0.77
T_5	67.73±13.18	62.64±13.06	0.35
T_6	64.86±16.79	64.78±11.11	0.6
T_7	62.93±17.19	60.64±7.67	1

Data are presented as mean±standard deviation.

No significant differences were found between the groups according to the mean arterial blood pressure values at the 1st, 2nd, 3rd, 4th, and 5th minutes after the intubation (p>0.05). Saturation values before the induction of anesthesia (T0), after induction (T1), and after intubation (T2) were 97.73±1.86, 98.6±1.5 and 98.4±1.68 in group 1 and 98.2±1.93, 98.53±1.54 and 98.26±1.38 in group 2, respectively. The saturation values measured at 1-minute-intervals for 5 minutes (T3, T4, T5, T6, T7) after the intubation were 97.73±1.83, 97.73±1.38, 98.06±1.22, 97.86±1.45, 97.86±1.5 in group 1; 98.13±1.35, 97.71±1.48, 97.64±1.54, 97.92±1.14 and 98±1.17 in group 2, respectively. No significant differences were found between the groups according to the saturation values at the 1st, 2nd, 3rd, 4th, and 5th minutes after the intubation (p>0.05) (Table 5). The end-tidal carbon dioxide values immediately after the intubation were 36.86±3.7 in group 1 and 35.35±3.17 in group 2 (p=0.11). Endtidal carbon dioxide (ETCO2) values at the 1st, 2nd, 3rd, 4th, and 5th minutes after intubation were 34.86±2.66, 33.86±3.71, 33.33±3.45, 33±3.31 and 33±2.8 in group 1 and 34.5±4.38, 33.5±4.1, 32.85±4.48, 32.07±4.28 and 31.85±4.48 in group 2, respectively. No significant differences were found between the groups according to ETCO2 values at the 1st, 2nd, 3rd, 4th, and 5th minutes after intubation (p>0.05). In the evaluation of intubation conditions in group 1, 1 point was

Table 5 Peripheral oxygen saturation result

	Group 1	Group 2	P
T_0	97.73±1.86	98.2±1.93	0.42
T_1	98.6±1.5	98.53±1.54	0.66
T_2	98.4±1.68	98.26±1.38	0.61
T_3	97.73±1.83	98.13±1.35	0.7
T_4	97.73±1.38	97.71±1.48	0.98
T_5	98.06±1.22	97.64±1.54	0.54
T_6	97.86±1.45	97.92±1.14	0.84
T_7	97.86±1.5	98±1.17	0.77

Data are presented as mean±standard deviation.

given in 1 (6.7%) case, 2 points were given in 2 cases (13.3%), 3 points were given in 7 (46.7%) cases, and 4 points were given in 4 (33.3%) cases for the evaluation of the application. In the evaluation of intubation conditions in group 2, 2 points were given in 3 (20%) cases, and 3 points were given in 12(80%) cases. In evaluating intubation conditions in groups, 2, 1, and 4 points were not given. No significant differences between the groups were found in the evaluation of intubation conditions (p=0.46). In the evaluation of intubation image quality in group 1, 1 point was given in 1 (6.7%) case, 2 points were given in 1 case (6.7%), 3 points were given in 7 (46.7%) cases, and 4 points were given in 6 (33.3%) cases. In the evaluation of intubation image quality in group 2, 1 point was given in 1 case (6.7%), 3 points were given in 13 (86.7%) cases, and 4 points were given in 1 (6.7%) case. In group 2, there were no applications in which 1 point was given to intubation image quality. The intubation image quality of both groups was similar (p=0.09). In the evaluation of intubation satisfaction lower than group 1, 1 point was given in 1 (6.7%) case, 2 points were given in 1 case (6.7%), 3 points were given in 9 (60%) cases, and 4 points are given in 4 (26.7%) cases. In the evaluation of intubation satisfaction in group 2, 1 point was given in 1 case (6.7%), 3 points were given in 13 (86.7%) cases, and 4 points were given in 1 (6.7%) case. In group 2, there were no applications in which intubation satisfaction was given 1 point. No significant differences were found in the groups' evaluation regarding intubation satisfaction (p=0.31). Early postoperative complications were not observed in both groups.

Discussion

Anesthesiologists who take an active role in aerosol-generating procedures such as endotracheal intubation are six times more at risk of coronavirus infection than other healthcare workers [5]. In patients infected with Covid-19, using a video laryngoscope as an alternative to direct laryngoscopy is recommended to protect the intubator from infection and reduce intubation failure due to personal protective equipment worn to prevent exposure to infection [4]. Also, aerosol cans used to reduce the risk of Covid-19 transmission during intubation may make it difficult to maneuver the laryngoscope. The present study evaluated and compared conventional video laryngoscope and 3D printed video laryngoscope. No differences were observed in intubation time, the number of intubation attempts, hemodynamic response, early postoperative complications, and satisfaction of the intubation practitioner.

In a randomized controlled trial comparing intubation with C MAC video laryngoscope and direct laryngoscopy using an aerosol can, it has been reported that video laryngoscope facilitated endotracheal intubation by providing direct visualization of the glottis [6]. Despite the advantages of the conventional video laryngoscope, its high cost makes it difficult to obtain in healthcare institutions. To the best of our knowledge, no studies evaluate the conventional video laryngoscope and the video laryngoscope developed with a 3D printer.

During endotracheal intubation, applying force to the tongue root with the laryngoscope causes sympathetic system activation and leads to hemodynamic changes. The hemodynamic response to intubation is well tolerated in healthy individuals. However, it may cause serious side effects in patients with limited coronary reserve [7]. Furthermore, a prolonged duration of laryngoscopy may exacerbate the intubation-induced hemodynamic response [8]. In that context, there are studies in the literature to evaluate the hemodynamic effects of intubation with different laryngoscope types. The present study included patients who underwent general anesthesia, aged 18-65 years, ASA1-2, and who were not considered to have a difficult airway, and hemodynamic response to intubation was evaluated employing four different laryngoscopes (Macintosh direct laryngoscope-classic laryngoscope, McCoy laryngoscope, McGrath video laryngoscope, and C-MAC video laryngoscope). Accordingly, heart rate, saturation, and systolic blood pressure were measured in the operating room at baseline (T0), immediately after induction (T1), immediately after intubation (T2), and for 5 minutes at 1-minute-intervals (T3, T4, T5, T6, T7). The number of intubation attempts did not differ between the groups. However, using the McGrath video laryngoscope has been reported to be advantageous in preventing cardiovascular stress response with fewer hemodynamic changes and shorter intubation time (7). In a study evaluating the hemodynamic response to intubation using a GlideScope video laryngoscope and a Macintosh direct laryngoscope, it has been reported that hemodynamic parameters were better preserved in the first three minutes after intubation when using the GlideScope video laryngoscope [9]. The present study showed no differences in intubation times between 3D printer video laryngoscope and conventional video laryngoscope. There was no difference in hemodynamic measurements (SAB, DAB, OAB, SpO2, ETCO2) during the pre-induction period, immediately after induction, immediately after intubation, and after 5 minutes with 1-minute intervals after intubation. This suggests that the 3D-printed video laryngoscope developed at a lower cost in the context of the present study has a similar hemodynamic effect to the conventional video laryngoscope.

Cormack-Lehane (C&L) scoring is used to grade the glottic appearance during direct laryngoscopy. So far, there is no definitive grading system for video laryngoscopes [10]. The present study recorded the C&L score by direct laryngoscopy employing a Macintosh laryngoscope in all patients before endotracheal intubation. The C&L score was significantly higher in the 3D-printed video laryngoscope group. However, the number of intubation attempts and duration were similar to the conventional video laryngoscope, with no significant differences. A 3D-printed video laryngoscope was thought to be as effective as a conventional video laryngoscope in providing a glottis view.

Following intubation, some complications including hoarseness, sore throat, and cough, can be seen in the early

postoperative period. Particularly, sore throat after endotracheal intubation is very common. Sex (female), young age, intubation with no neuromuscular blockades, pulmonary diseases, double lumen tube use, and high-cuff pressure may increase the incidence of sore throat [11]. The present study did not detect early postoperative complications using two video laryngoscopes. This was because the patients in both groups did not differ in age, sex, or comorbid diseases, using neuromuscular agents before intubation using a single lumen tube. Experienced anesthesiologists performed all intubations.

The present study evaluated the image quality and user satisfaction of the two video laryngoscopes by the person performing the intubation. The results in the present study showed no differences between the groups. Therefore, it was thought that the technical features of the 3D-printed video laryngoscope, including the ability to maneuver the laryngoscope and image quality, are similar to the conventional video laryngoscope.

Limitations

The present study had some limitations. The first was that the study included the ASA1-2 patient group in whom a difficult airway was not considered. This does not reflect the group of patients with severe comorbid diseases in whom a difficult airway was considered. Secondly, cuff pressure after intubation was not recorded, which would provide a better idea in evaluating early postoperative complications.

Conclusion

The present study compared a 3D-printed video laryngoscope with a conventional video laryngoscope. No differences were observed in intubation time, the number of intubation attempts, hemodynamic changes, and early postoperative complications related to intubation. Intubation satisfaction by the practitioner was found to be similar. It was thought that the 3D-printed video laryngoscope, which is cost-effective and has easy access, could be used as an alternative to conventional video laryngoscope in patients with normal airways. Nevertheless, prospective and multicase studies are needed for more definitive results.

Disclosures: There is no conflict of interest for all authors.

Acknowledgments: None.

Funding: None.

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