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Haemodynamic response to endotracheal intubation using direct laryngoscopy vs. Bonfils retromolar fiberscope: A prospective randomized comparative study

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Abstract

Background and Aims: Direct laryngoscopy (DL) is the traditional method for Endotracheal intubation (ETI), but it often results in more pronounced haemodynamic responses. Bonfils retromolar fiberscope, a more recent alternative, has been proposed as a potentially better option in terms of reducing these responses. This study aimed to compare the haemodynamic effects, time to intubation, and complication rates between these two techniques to determine the optimal approach, especially for patients at risk of cardiovascular complications.

Materials and Methods: This prospective randomized comparative study was conducted on 60 patients, randomly allocated to two groups: Group D (n=30) underwent ETI via DL using a Macintosh blade, and Group R (n=30) had ETI via Bonfils retromolar fiberscope. Haemodynamic parameters, including SBP, DBP, MAP, HR, and SpO_2, were recorded immediately after ETI and at 1-minute intervals for the next 10 minutes. Procedural complications, such as mucosal injury, lip injury, dental injury, and sore throat, were documented. Time to intubation (TTI) was recorded from the insertion of the laryngoscope or Bonfils to its removal after successful placement of the endotracheal tube (ETT).

Results: The haemodynamic response to ETI was significantly higher in Direct laryngoscopy group [$P<0.05$ for SBP, DBP, MAP and HR]. Time to intubation (TTI) was significantly higher in Bonfils retromolar fibrescope group. Although complications such as sore throat, lip injury, and hoarseness were more common in Group D, these differences were not statistically significant ($P>0.05$).

Conclusion: Bonfils retromolar fiberscope results in a lesser haemodynamic response to tracheal intubation compared to direct laryngoscopy, making it beneficial in patients with cardiovascular diseases. However, the time to intubation is longer with Bonfils, which could decrease with more frequent use due to a longer learning curve.

Keywords: Laryngoscopy, Haemodynamic response, Bonfils retromolar fiberscope.

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1. Introduction

Endotracheal intubation (ETI) is the gold standard in airway management as a means to administer general anaesthesia (GA). Macintosh laryngoscope is the standard laryngoscope used for ETI, though advances in science have resulted in the development of several laryngoscopes of different designs.[1–3] The process of laryngoscopy and intubation (L&I) can result in significant haemodynamic response (HDR). Hence, taming this response is a topic of research. Cardiovascular response to ETI is initiated by glossopharyngeal nerve (stimulus superior to anterior surface of epiglottis) and vagus nerve (stimulus below posterior epiglottis down into the lower airway). The process of L&I results in diffuse autonomic response with release of norepinephrine from adrenergic nerve terminals, and epinephrine from adrenal medulla along with activation of the renin-angiotensin system.[4] These changes were first described by Reid and Brace.[5] It is initiated within 5 seconds of direct laryngoscopy, further increase with the passage of the endotracheal tube (ETT) and return to normal level by 5 minutes.[6] The magnitude of this cardiovascular response is directly related to the force and duration of laryngoscopy.[7] This HDR leads to rise in heart rate (HR), blood pressure (BP), myocardial

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oxygen demand, and incidence of dysrhythmias. The rise in HR and BP is usually transient and variable. Although such a response would likely be tolerated well by healthy patients, it may be associated with complications such as myocardial ischemia, dysrhythmia and cerebral hemorrhage in those with significant coronary artery or cerebrovascular diseases.[8] In principle, ETI techniques that avoid or minimize stimulation of the oropharynx and larynx might attenuate the HDR.[9] Methods to attenuate these responses, both pharmacological and otherwise, have been extensively studied.[10-12] The Macintosh laryngoscope continues to be the primary choice for routine airway management for most Anaesthetists owing to the widespread availability, lower cost and ease of use. However, direct laryngoscopy may fail in 1.5% to 8.5% of the population despite appropriate operator experience, adequate patient positioning and mouth opening.[13] Also, it can cause other complications like oropharyngeal/ mucosal/ dental injuries and sore throat. Such injuries may be reduced by intubation techniques which do not need conventional laryngoscopy such as retromolar intubation using the Bonfils retromolar fiberscope.

Bonfils retromolar fiberscope is a thin, rigid, 40 cm long fiberoptic endoscope used for ETI.[14,15] This video assisted intubation fiberscope allows visualization of the laryngeal inlet and placement of the ETT under direct vision. Using the retromolar approach, the scope is inserted from the right side of the patient's mouth, alongside the molars, and advanced beneath the epiglottis. It is then guided through the glottic opening until the tracheal rings are identified, allowing the ETT to be inserted using gentle corkscrew motions.[14,15] Theoretically, by avoiding the more invasive direct laryngoscopy, Bonfils minimizes oropharyngeal stretch and stimulation, which could attenuate the haemodynamic response (HDR). Keeping this in consideration, our study aimed to compare HDR and other key parameters between the conventional Macintosh laryngoscope and Bonfils retromolar fiberscope. The primary objective was to assess the HDR to ETI using these two techniques in patients undergoing elective surgery under general anaesthesia (GA). The secondary objectives included comparing the time to intubation, number of attempts, and rates of mucosal, lip, and dental injuries, as well as any failures, between the two groups.

2. Materials and Methods

This prospective randomized and comparative study was conducted in a tertiary care teaching hospital. Approval from Institutional Ethics committee [ECR/779/Inst/MH2015] was taken. Sixty patients aged between 18 to 60 years, belonging to ASA grade I and II, undergoing elective surgery under GA, and requiring ETI were included. Patients with ASA Grade III and above, anticipated difficult airway/mask ventilation, those requiring rapid sequence induction, pregnancy, age <18 years and >60 years, hypertension, ischemic heart disease and patients not willing to participate in the study were excluded. The eligible patients who met the inclusion criteria were randomly allocated into two groups of 30 each, using a computer-generated random number table and group assignment via a sealed opaque envelope technique. Group D underwent ETI using direct laryngoscopy, while GROUP R underwent ETI using Bonfils retromolar fiberscope (Karl Storz).

The study details were thoroughly explained to each patient in a language they could easily understand. Written informed consent was obtained, ensuring the confidentiality of the patients' data and identities. Prior to the procedure, all patients underwent a pre-anaesthetic check-up (PAC), which included a comprehensive history, physical examination, and necessary laboratory investigations. Patients were kept nil by mouth (NBM) in accordance with standard guidelines. In the pre-operative area, patients were connected to standard monitoring equipment, including non-invasive blood pressure (NIBP), ECG, and pulse oximeter. After ensuring the patients' comfort, baseline haemodynamic parameters (HR, SBP, DBP, MAP, and SpO2) were recorded after a 10 minute stabilization period.

In the operating room, pre-oxygenation was performed with 100% oxygen at 8 liters per minute for 3 minutes. Both groups received Fentanyl 2 µg/kg, Propofol 2.5 mg/kg, and Atracurium 0.5 mg/kg IV. Afterward, patients were ventilated for 3 minutes with 2 liters/min of oxygen, 3 liters/min of N_2O, and 2% Sevoflurane to allow Atracurium to take effect. Haemodynamic response (HDR) was recorded before laryngoscopy (BL). Cuffed Portex PVC tracheal tubes (7.5 mm for females, 8.5 mm for males) were used for ETI. In Group D, ETI was performed using direct laryngoscopy with a Macintosh blade, while in Group R, Bonfils retromolar fiberscope was used. Anaesthesia was maintained with sevoflurane, N2O, and oxygen at a MAC of 1, with Fentanyl and Atracurium top-ups as needed. HDR was recorded immediately after ETI and at 1-minute intervals for 10 minutes. Intraoperative monitoring included ECG, $EtCO_2$, SpO_2, NIBP, and airway pressure. Surgical incision was made 10 minutes post-ETI. Complications such as mucosal, lip, dental injuries, and sore throat were noted. "Time to intubation (TTI)" was calculated from insertion to removal of the laryngoscope or Bonfils after ETT placement.

The data was collected, entered, and compiled using Microsoft Excel and analyzed using Epi Info version 7.2. A sample size of 60 was estimated based on the study by Kihara S et al., with a Type 1 error of 0.05, power of 0.8, and a significance level of $P < 0.05$.[9] Qualitative variables were expressed as percentages, and the difference between two proportions was tested using Fisher's exact or Chi-square test. Quantitative variables were presented as mean and standard deviation or categorized as percentages. The difference between two means was tested using the Student's t-test. All analyses were two-tailed, and the significance level was set at 0.05.

3. Results

The demographic variables of the subjects are shown in **Table 1**. Both the groups were demographically comparable with respect to age, gender, weight and ASA grading [P > 0.05 each].

The baseline HR was 73.97 ± 8.66 and 73.17 ± 7.10 in Group D and Group R respectively, and this difference was not statistically significant. Among both the groups, there was a drop in mean HR values after induction of GA and before Laryngoscopy and later increased. In Group D, the HR increased to a peak at 2 minutes after ETI (88.97 ± 7.86) and reached the baseline values by 7 minutes after ETI. In Group R, there was a similar peak and fall in the HR, but the values remained lower when compared to Group D. After ETI to 6 minutes after ETI, the difference between the HR in both the groups was significant (P <0.05, **Table 2** and **Figure 1**).

The baseline SBP was 124.13 ± 8.04 and 125.13 ± 9.24 in Group D and Group R respectively and this difference was not statistically significant. Among both the groups there was a drop in the mean SBP levels before Laryngoscopy and later increased. In Group D, the SBP increased to a peak at 2 min after ETI (139.47 ± 5.05) and reached the baseline levels by 7 min after ETI. In Group R, there was a similar peak and fall in the SBP but it was lower when compared to Group D. From 1 min to 6 min, the difference between the SBP among the groups was significant (P <0.05, **Table 2** and **Figure 2**).

The DBP was 77.73 ± 6.75 and 78.80 ± 7.62 in Group D and Group R respectively and this difference was not statistically significant. Among both the groups there was a drop in mean DBP levels before Laryngoscopy and later increased. In Group D, the DBP increased to a peak at 2 min after ETI (88.33 ± 4.44) and reached the baseline levels by 5 min after ETI. In Group R, there was a similar peak and fall in the DBP but it was lower when compared to Group D. After ETI to 4 min after ETI, the difference between the DBP among the groups was significant (P <0.05, **Table 2** and **Figure 3**).

The baseline MAP was 93.20 ± 6.79 and 94.24 ± 7.76 in Group D and Group R respectively and this difference was not statistically significant. In both the groups there was a drop in MAP levels before Laryngoscopy and later increased. In Group D, the MAP increased to a peak at 2 min after ETI (105.38 ± 4.22) and reached the baseline values by 5 min after ETI. In Group R, there was a similar peak and fall in the MAP, but was lower when compared to Group D. After ETI to 5 min post-intubation, the difference between the MAP among the groups was significant (P <0.05, **Table 2** and **Figure 4**).

The mean TTI in Group R was 46.23± 9.67 seconds, which was significantly higher (P <0.001) than 31.93 ±3.77 seconds in Group D (**Figure 5**). In Group D, 93.33% needed a single attempt and 6.67% needed two attempts. In Group R, 90% needed a single attempt and 10% needed two attempts. There was no significant difference between the proportions between the two groups (P = 1). In Group D, 10% had hoarseness, 3.33% had lip injury and 13.33% had sore throat. In Group R, 3.33% had hoarseness, none had lip injury and 3.33% had sore throat. There was no significant difference between the proportion of complications among the groups (P >0.05).

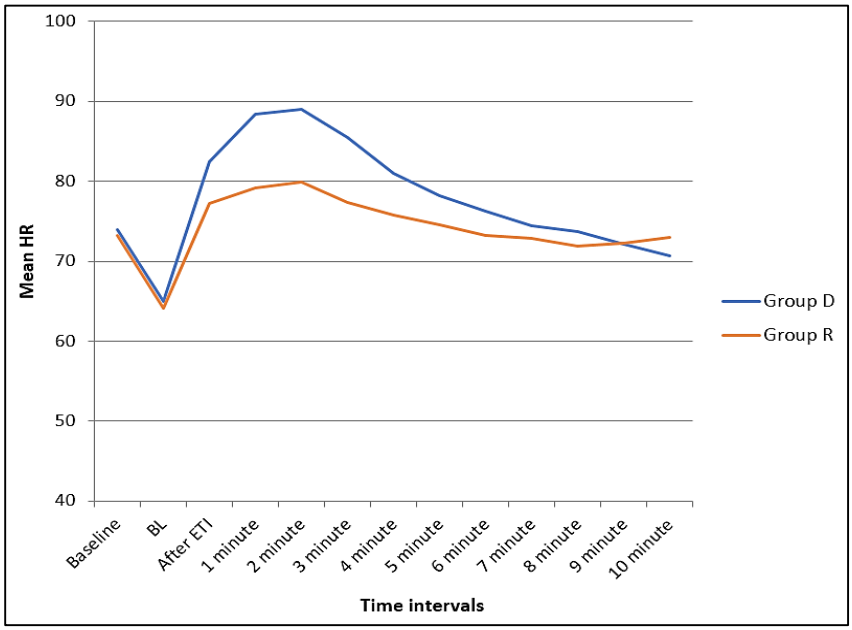

Figure 1: Mean heart rate [beats/min] in the two groups at various time intervals

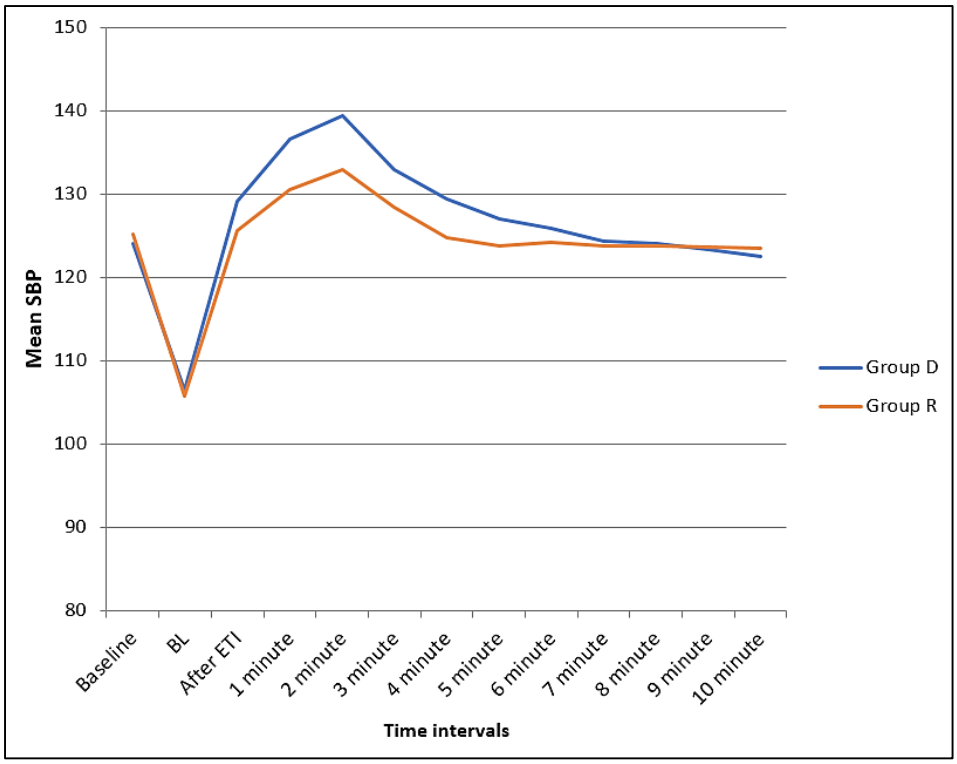

Figure 2: Mean systolic BP [mm Hg] in the two groups at various time intervals

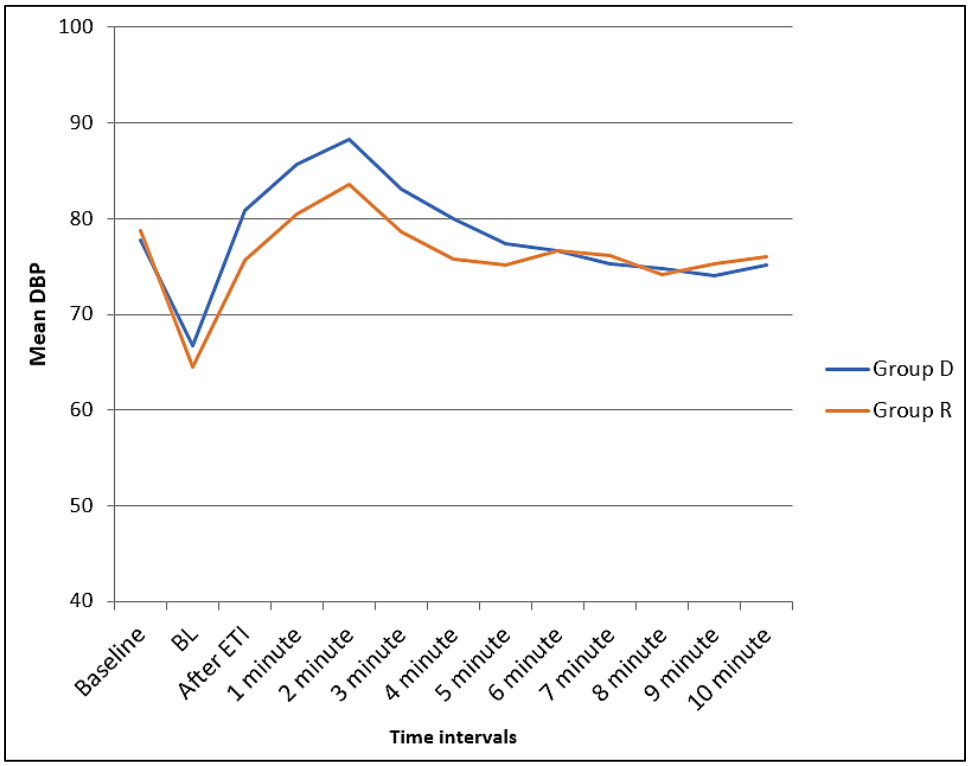

Figure 3: Mean diastolic BP [mm Hg] in the two groups at various time intervals

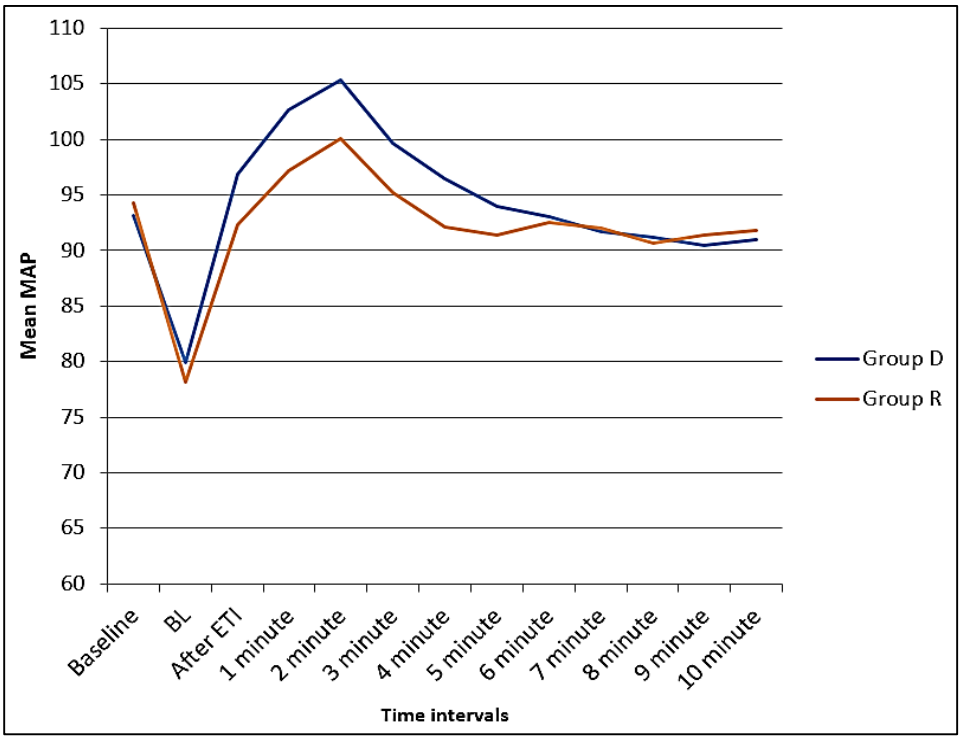

Figure 4: Mean MAP [mm Hg] in the two groups at various time intervals

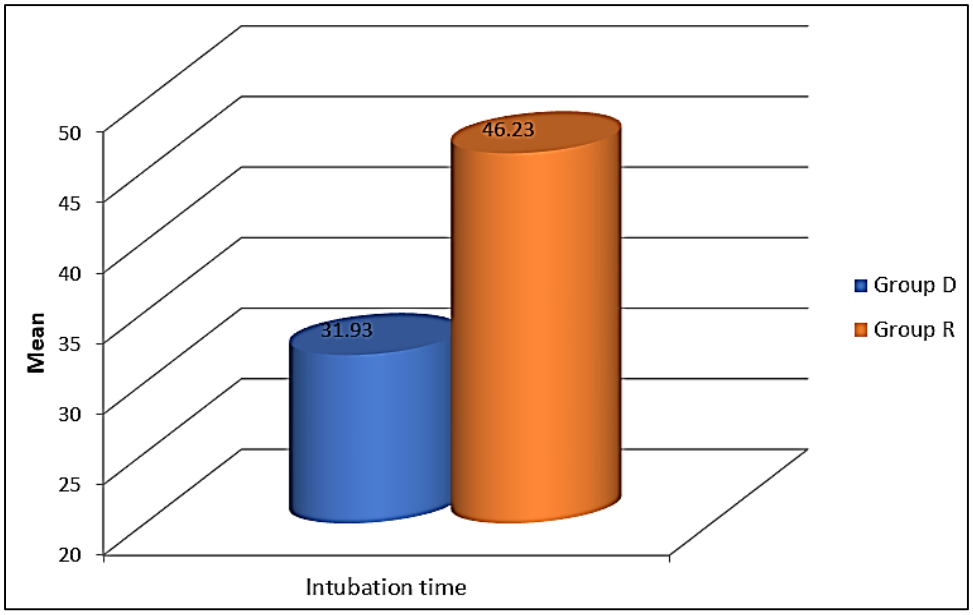

Figure 5: Distribution of study subjects based on Time to Intubation [TTI] in seconds

Table 1: Demographic characteristics

	Group D [n = 30]	**Group R** [n = 30]	**P value**
Age [years]	32.63 ± 12.35	34.90 ± 12.49	0.4471
Gender [F/M]	18/12	23/7	0.1624
Weight [Kg]	51.57 ± 7.99 kg	49.40 ± 8.95 kg	0.3266
ASA Grade [I/II]	28/2	26/4	0.3894

Note: Values are in mean ± SD.

Table 2: Comparison of hemodynamics in both the groups

Time Point	HR (Gp.D)	HR (Gp. R)	HR p value*	SBP (Gp. D)	SBP (Gp. R)	SBP p value*	DBP (Gp. D)	DBP (Gp. R)	DBP p value	MAP (Gp. D)	MAP (Gp. R)	MAP p value*
Baseline	73.97 ± 8.66	73.17 ± 7.10	0.6970	124.13 ± 8.04	125.13 ± 9.24	0.6564	77.73 ± 6.75	78.80 ± 7.62	0.5682	93.20 ± 6.79	94.24 ± 7.76	0.5812
BL	65.00 ± 7.47	64.17 ± 5.67	0.6287	106.40 ± 8.24	105.70 ± 8.04	0.7404	66.70 ± 5.06	64.47 ± 6.83	0.1553	79.93 ± 5.61	78.21 ± 6.93	0.2946
After ETI	82.47 ± 9.53	77.17 ± 7.13	0.0179	129.07 ± 6.71	125.63 ± 7.47	0.0661	80.83 ± 6.18	75.60 ± 6.68	0.0026	96.91 ± 6.05	92.28 ± 5.86	0.0038
1 min	88.43 ± 9.95	79.17 ± 7.07	<0.001	136.60 ± 4.62	130.50 ± 7.36	<0.001	85.73 ± 3.89	80.53 ± 6.30	0.0003	102.69 ± 3.81	97.19 ± 6.23	0.0001
2 min	88.97 ± 7.86	79.93 ± 6.60	<0.001	139.47 ± 5.05	132.97 ± 7.30	0.0002	88.33 ± 4.44	83.60 ± 6.37	0.0015	105.38 ± 4.22	100.06 ± 6.26	0.0003
3 min	85.50 ± 6.97	77.30 ± 5.76	<0.001	132.90 ± 5.93	128.37 ± 10.51	0.0442	83.03 ± 5.02	78.63 ± 6.92	0.0066	99.66 ± 5.03	95.21 ± 7.76	0.0109
4 min	80.97 ± 6.74	75.73 ± 5.69	0.0019	129.43 ± 4.97	124.83 ± 11.05	0.0421	80.03 ± 5.56	75.80 ± 7.77	0.0184	96.50 ± 4.88	92.14 ± 8.50	0.0181
5 min	78.20 ± 6.51	74.57 ± 5.97	0.0281	127.00 ± 5.33	123.83 ± 7.53	0.0652	77.43 ± 4.82	75.20 ± 4.94	0.0817	93.96 ± 4.45	91.41 ± 5.29	0.0485
6 min	76.30 ± 6.32	73.20 ± 5.61	0.0492	125.93 ± 5.84	124.20 ± 7.12	0.3068	76.67 ± 4.77	76.63 ± 6.36	0.9818	93.09 ± 4.81	92.49 ± 6.04	0.6718
7 min	74.47 ± 6.88	72.90 ± 6.24	0.3596	124.37 ± 6.92	123.73 ± 8.21	0.7479	75.30 ± 4.38	76.13 ± 5.06	0.4978	91.66 ± 4.70	92.00 ± 5.63	0.7979
8 min	73.67 ± 6.94	71.87 ± 6.36	0.2991	124.00 ± 6.79	123.83 ± 7.55	0.9287	74.77 ± 4.72	74.17 ± 13.73	0.8218	91.18 ± 5.13	90.72 ± 9.49	0.8178
9 min	72.10 ± 7.16	72.27 ± 6.49	0.9251	123.43 ± 7.47	123.63 ± 7.37	0.9172	74.00 ± 4.74	75.23 ± 5.50	0.3561	90.48 ± 5.37	91.37 ± 5.50	0.5290
10 min	70.67 ± 7.02	73.00 ± 6.69	0.1925	122.57 ± 6.68	123.47 ± 7.96	0.6371	75.20 ± 5.59	76.00 ± 5.95	0.5935	90.99 ± 5.11	91.82 ± 6.12	0.5692

*Independent Student's t test

4. Discussion

The demographic data in terms of age, sex, weight and ASA grade were comparable in both the groups. The baseline haemodynamic parameters (HR, SBP, DBP, MAP) were comparable in both the groups.

There was a decrease in mean heart rate (HR) from baseline in both groups after induction, prior to laryngoscopy. Following Endotracheal intubation (ETI), HR values increased in both groups, peaking at 2 minutes, and remained elevated for 6 minutes post-ETI. The rise in HR was observed in both groups, but the increase was significantly higher in Group D ($P < 0.05$). By 7-10 minutes after ETI, HR values returned to baseline.

Blood pressure (BP) values initially decreased after induction in both groups, prior to laryngoscopy. Following ETI, systolic blood pressure (SBP) and diastolic blood pressure (DBP) increased for up to 4 minutes, peaking at 2 minutes. Mean arterial pressure (MAP) values rose up to 5 minutes after ETI, also peaking at 2 minutes. This increase in BP was observed in both groups, but it was significantly higher in Group D compared to Group R, with statistically significant results ($P < 0.05$)

The typical fall in the haemodynamic parameters from the baseline before laryngoscopy can be attributed to the vasodilatation resulting from induction of GA. Laryngoscopy and intubation are intensely stimulating procedures and produce marked sympathetic response. Traction on the supra glottic region during direct laryngoscopy is one of the factors responsible for producing this response.[16] Maximum stimulus is generated by the stimulation of the vallecula by direct laryngoscopy, followed by nose, nasopharynx, and tracheobronchial tree.[17] In contrast, the Bonfils retromolar fiberscope helps minimize this sympathetic response by reducing oropharyngeal stimulation, which could explain the reduced haemodynamic response (HDR) observed in our study. Additionally, the Bonfils fiberscope is introduced under direct vision, allowing for precise placement of the endotracheal tube (ETT) with minimal contact with the epiglottis, further contributing to a gentler haemodynamic impact.

The results of our study are consistent with those of Boker et al., where both mean arterial pressure (MAP) and heart rate (HR) values were significantly higher in the direct laryngoscopy group during the 5 minutes following endotracheal intubation (ETI), compared to the retromolar group.[18] Similarly, Ghoneim et al. demonstrated a significant increase in HR and MAP in the direct laryngoscopy group compared to the Bonfils group, from before ETI until 5 minutes post-ETI.[19] Additionally, Senapathi TG et al. found that the Bonfils retromolar fiberscope provided better haemodynamic stability compared to the Macintosh videolaryngoscope.[20]

However, Hosdurg B et al. found no statistically significant difference between the direct laryngoscopy and Bonfils groups in terms of changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and heart rate (HR) throughout the study period.[21] This could be attributed to the administration of lignocaine 1.5 mg/kg before intubation in both groups, as lignocaine has been shown to reduce the haemodynamic response to laryngoscopy and intubation (L&I), as demonstrated in studies by Splinter WM et al., Wilson IG et al., and Kocamanoglu IS et al.[22-24]

The time to intubation (TTI) was significantly higher in Group R (46.23 ± 9.67 seconds) compared to Group D (31.93 ± 3.77 seconds) ($p < 0.001$). Prolongation of the intubation duration has been associated with increased haemodynamic changes after tracheal intubation.[17] This could explain the rise in haemodynamic parameters observed in Group R, although these changes were still lower than in Group D. In Group D, 93.33% of patients were intubated on the first attempt, while 6.67% required a second attempt for successful intubation. There were two cases in which intubation could not be achieved even after a third attempt with the Bonfils fiberscope. These patients were ventilated with bag and mask using oxygen, nitrous oxide, and sevoflurane, and then successfully intubated using direct laryngoscopy. These two patients were excluded from the study. The difficulty in intubation was due to copious secretions that obscured the laryngeal view. While oropharyngeal suctioning improved the view, it was still insufficient to allow successful endotracheal tube placement through the vocal cords.

Byhahn and co-workers found that using a standard Macintosh laryngoscope blade significantly improved the ease of inserting the Bonfils fiberscope and enhanced visualization of the glottic aperture.[25] This combination reduced the procedure time from 35–40 seconds to 20–25 seconds. They concluded that the learning curve for the Bonfils fiberscope is steep, and typically, 10 supervised intubations are sufficient to develop the necessary skills for independent use, even under less optimal conditions. Halligan also studied the learning curve for Bonfils among anaesthesiologists and suggested that proficiency is typically achieved after 20–25 intubations.[26]

Complications like sore throat, lip injury and hoarseness were higher in Group D as compared to Group R, but the difference was not statistically significant. This could be attributed to the technique of insertion of the direct laryngoscope and also the force applied to the base of the tongue during direct laryngoscopy. Boker et al. and Hosdurg B et al. both reported a significantly lower incidence of sore throat and hoarseness in the Bonfils group compared to the direct laryngoscopy group.[18,21] Similarly, Senapathi TG et al. observed that the Bonfils retromolar fiberscope reduced the incidence of sore throat compared to the Macintosh video

laryngoscope in patients undergoing general anaesthesia (GA).[20]

This study also had several limitations. It included only normotensive patients, and those with anticipated difficult airways or mask ventilation were excluded. While haemodynamic response was assessed by measuring parameters such as HR, SBP, DBP, and MAP, serum catecholamine levels were not measured, which could have provided additional insight. There may have been potential observer bias in recording the haemodynamic parameters. Additionally, a larger sample size and a multicenter study would have provided more robust and generalizable results.

5. Conclusion

Use of Bonfils retromolar fiberscope results in a lesser haemodynamic response to tracheal intubation compared to direct laryngoscopy, which is advantageous in patients with cardiovascular diseases. Time to intubation is longer with the Bonfils retromolar fiberscope due to a longer learning curve and may decrease with more frequent use of the device.

6. Source of Funding

None.

7. Conflict of Interest

None.

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