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Comparison of endotracheal intubation with Macintosh versus King Vision video laryngoscope using coronavirus disease 2019 barrier box on manikins: A randomized crossover study

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Abstract:

BACKGROUND: Coronavirus disease 2019 (COVID-19) virus usually spreads through aerosol and close contact. Frontline health-care workers handle aerosol-generating procedures like endotracheal intubation. To reduce this risk, COVID-19 barrier box came into the picture. However, the COVID-19 barrier box may compromise easy and successful intubation, and their limitation must be studied.

OBJECTIVES: The objective of this study was to assess the time to successful intubation with or without the COVID-19 barrier box using the Macintosh laryngoscope and King Vision video laryngoscope (KVVL). We also assessed the first-pass success rate, ease of intubation, Cormack–Lehane (CL) grade, and requirement of external laryngeal manipulation.

METHODS: We conducted this manikin-based randomized crossover study to assess the time to successful intubation by anesthesiologists (22) and emergency physicians (11) having 1 year or more experience with or without COVID-19 barrier box by using the Macintosh laryngoscope and KVVL. Our study randomized the sequence of the four different intubation scenarios.

RESULTS: The comparison of mean duration of intubation between KVVL (13.21 ± 4.05 s) and Macintosh laryngoscope (12.89 ± 4.28 s) with COVID-19 barrier box was not statistically significant (95% confidence interval: 1.21–0.97). The ease of intubation, number of attempts, and requirement of external laryngeal manipulation were not statistically significant. Intubations were statistically significant more difficult with barrier box in view of higher CL grade.

CONCLUSION: Time to intubation was longer with COVID-19 barrier box using KVVL as compared to Macintosh laryngoscope which was statistically not significant.

Keywords:

Coronavirus disease 2019, intubation, King Vision video laryngoscope, Macintosh laryngoscope, manikin

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Introduction

Coronavirus disease 2019 (COVID-19) was declared as pandemic by the WHO on March 11, 2020. The causative organism of the disease (severe acute respiratory syndrome-coronavirus-2) usually spreads through droplets and aerosols. Various aerosol-generating procedures such as endotracheal intubation and bag-mask ventilation are being performed by frontline

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Box-ED section

What is already known on the study topic?

- Coronavirus disease 2019 (COVID-19) is very contagious and spreads through aerosol. The highest viral load of severe acute respiratory syndrome-coronavirus-2 appears in sputum and upper airway secretions. Frontline health-care workers performing various aerosol-generating procedures such as endotracheal intubation are at risk. This COVID-19 barrier box has proven to reduce the aerosol spread during endotracheal intubation.

What is the conflict on the issue? Has it important for readers?

- Macintosh laryngoscope is commonly used laryngoscope in the emergency department. The King Vision video laryngoscope (KVVL) is a portable, inexpensive, and suitable for use in the emergency department. Using these laryngoscopes with the COVID-19 barrier box may compromise easy and successful intubation, and their limitation must be studied.

How is this study structured?

- Our study is a manikin-based randomized crossover study to assess the time to successful intubation by the emergency physicians and anesthesiologists having 1 year or more experience with or without COVID-19 barrier box by using the Macintosh laryngoscope and KVVL.

What does this study tell us?

- Both Macintosh laryngoscope and KVVL can be used for intubation with COVID-19 barrier.

health-care workers.[1] The COVID-19 pandemic is continuing and creating serious challenges to the health-care personnel involved in airway management. Various tools have been invented to curtail this risk to the person managing the airway, like the aerosol box.[2] The COVID-19 barrier box covers the patient's head and neck and effectively reduces the aerosol spread during endotracheal intubation.[3-5] Further, the COVID-19 barrier box without negative pressure may increase the risk to patients and health-care providers.[6-9]

Although the need for a change in intubation practice through barriers to reduce the aerosol spread is apparent, it will not be without a learning curve. The Macintosh laryngoscope is used commonly in the emergency department, intensive care units, and operation theater. The King Vision video laryngoscope (KVVL) (AMBU, Denmark) is another portable, inexpensive, and suitable option for the emergency department. Using these laryngoscopes with the aerosol box may compromise easy and successful intubation. Therefore, their limitations or benefits must be studied.

We conducted this manikin-based study to assess the time to successful intubation by anesthesiologists and emergency physicians having 1 year or more experience with or without aerosol box using the Macintosh laryngoscope and KVVL. We also assessed the first-pass success rate, ease of intubation, Cormack–Lehane (CL) grade, and requirement of external laryngeal manipulation.

Methods

Study type

This study was a manikin-based randomized crossover study. After getting approval from the Institute Ethics committee (IEC NO-T/IM-NF/TandEM/20/39 dated November 12, 2020), it was registered in the Clinical Trials Registry-India (CTRI/2021/02/031052).

Study population

Participants were the faculty members and residents of the anesthesia and emergency medicine departments who had experience of intubation for more than 1 year and familiar with using both KVVL and Macintosh laryngoscope. Participant refusal was taken as exclusion criteria. Written informed consent was obtained from each participant before the study.

Study design

The participants practiced intubation 20 times on manikin with COVID-19 barrier box: 10 times using Macintosh laryngoscope and 10 times using KVVL after demonstration by the investigators (SS, UH, CM, NS, and SD). The intubation was done in a simulated environment. The Airway Trainer Manikin (Laerdal Medical, Stavanger, Norway) was used for practice and study. The COVID-19 barrier box used was a modified version of the basic model by Sahoo *et al*.[10,11] [Figure 1]. In the basic model, visualization of the vocal cord was not proper due to the right-angle joint. Hence, the height of the vertical wall and the length of the horizontal roof were decreased, and an additional slanting roof was made, which improved the visualization of the vocal cord. Moreover, the creation of side opening helped in providing backward-upward-rightward pressure, suction, and bougie. All the participants were acquainted with the COVID-19 barrier box before doing the study. All intubations were done using either a size 3 Macintosh blade or channeled version of the KVVL blade, with a cuffed 7.5-mm internal diameter endotracheal tube (Smiths Medical, St. Paul, MN, USA). The lubricant was used with both the blade and the endotracheal tube while using the KVVL. An investigator was there to help with the equipment or external laryngeal manipulation

on request. Timekeeping was done by the person not involved in the study during both practice and study intubations. We recorded the intubation time in seconds, the number of attempts, any need for external laryngeal manipulation, ease of intubation, and CL grade.

Randomization and blinding

A computer-generated simple random sequence was used to assign study participants to four different scenarios. This randomization only ensured the intubation sequence of different scenarios (A, B, C, and D) [Figures 2 and 3]. It was an open-level randomized crossover study.

Scenario A: Intubation with Macintosh laryngoscope without COVID-19 barrier box.

Scenario B: Intubation with Macintosh laryngoscope with COVID-19 barrier box.

Scenario C: Intubation with KVVL without COVID-19 barrier box.

Scenario D: Intubation with KVVL with COVID-19 barrier box.

Outcomes

The primary outcome was the time required for successful intubation, defined as the time duration from the insertion of the laryngoscope blade to the first lung inflation using a self-inflating resuscitation bag after endotracheal tube cuff inflation. The secondary outcomes include ease of intubation, number of attempts, requirement of external laryngeal manipulation, and CL grading.

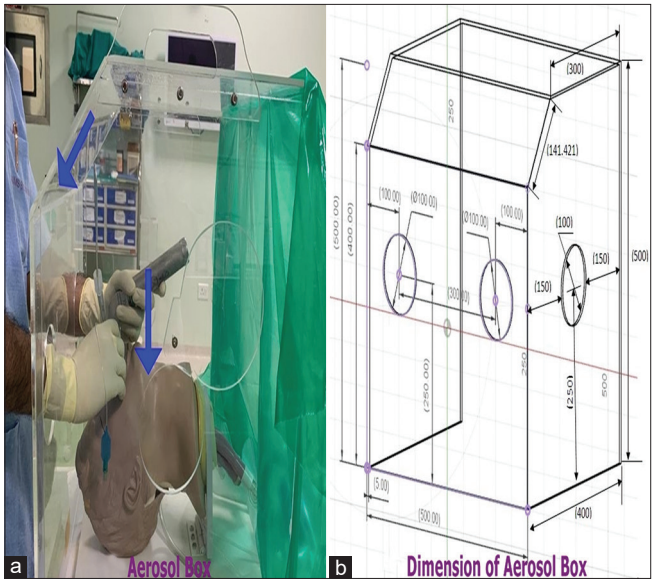

Figure 1: (a) aerosol box (b) dimension of aerosol box

Sample size calculation

A study by Park *et al*. reported that the time for successful intubation using Macintosh direct laryngoscopy was 20 s, with a standard deviation of 10 s.[12] The sample size was calculated to detect a 5-s difference with an alpha value of 0.05 and power of 80%. A sample size of 33 was required to achieve the required power.

Statistical analysis

Data were analyzed in SPSS version 27 (IBM Corp., Armonk, New York, USA). Categorical variables were expressed in frequency and percentages, and continuous variables were expressed in mean (standard deviation) or median (interquartile range [IQR]). The normality of the continuous variables was assessed using Shapiro–Wilk's test, and except for age and years of experience, all the variables were normally distributed. Pairwise comparison of dichotomous variables was performed using McNemar's test, and for multinomial variables, marginal homogeneity test was used. Comparison between two means was carried out using the paired sample *t*-test. The 95% confidence intervals (CIs) were also calculated for the differences. Spearman correlation test was used to analyze the correlation between duration of intubation and years of experience.

Results

The median age of the performing physicians was 30 years, ranging from 24 to 42 years. The majority were male (26, 78.8%). Out of the 33 physicians included in the study, 9 (27.3%) were teaching faculty, and 24 (72.7%) were residents. Among them, 11 were emergency physicians, while 22 were anesthesiologists.

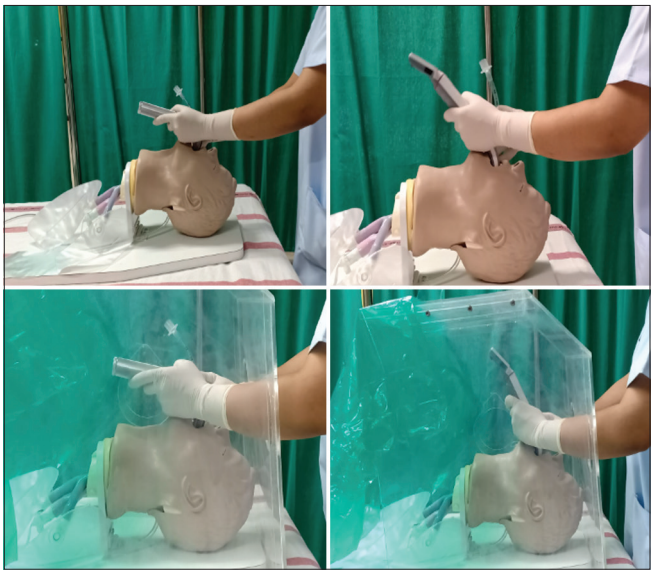

Figure 2: Intubation using Macintosh laryngoscope and KVVL with and without COVID-19 barrier box. COVID-19: Coronavirus disease 2019, KVVL: King Vision video laryngoscope

The median years of experience was 4 years (IQR [25th–75th percentile]: 2.25–7) [Table 1].

The comparison of mean duration of intubation using Macintosh blade with (12.89 ± 4.28 s) and without (11.82 ± 4.25 s) COVID-19 barrier box was not statistically significant (95% CI: 0.04–2.18) [Table 2]. The comparison of mean duration of intubation with KVVL laryngoscope with (13.21 ± 4.05 s) and without (12.08 ± 3.73 s) COVID-19 barrier box was not statistically significant (95% CI: 0.47–1.85) [Table 3]. Similarly, we did not find any statistically significant difference between the Macintosh laryngoscope and KVVL with barrier box (95% CI: 1.21–0.97) [Table 4]. Ease of intubation, number of attempts, and requirement of external laryngeal manipulation were not statistically significant with or without the COVID-19 barrier box. Second intubation attempts were required three times each for both the laryngoscopes with barrier box. There was a statistically significant higher CL grade (CL Grade 2) in case of Macintosh laryngoscope compared to KVVL with COVID-19 barrier box (95% CI: 0.06–0.52). There was a significant correlation between the duration of intubation with Macintosh laryngoscope and the years of experience (r= –0.420), but weak correlation between the duration of intubation with KVVL and years of experience (r = –0.146) [Figure 4].

Table 1: Demographic characteristics of the study participants

Variables	Median IQR (25th-75th percentile) or *n* (%)
Age (years)	30 (28.0-35.5)
Gender	
Male	26 (78.8)
Female	7 (21.2)
Designation	
Faculty	9 (27.3)
Resident	24 (21.2)
Department	
Anesthesia specialist	22 (67.6)
Emergency specialist	11 (32.4)
Years of experiences	4 (2.25-7.0)

IQR: Interquartile range

Discussion

We did not find any significant difference in the intubation time with the Macintosh laryngoscope blade and KVVL with or without the COVID-19 barrier box. With the COVID-19 barrier box, the average duration of intubation using KVVL was 13.21 ± 4.05 s, whereas the duration was 12.89 ± 4.28 s with the Macintosh laryngoscope. Intubations were statistically significant more difficult with barrier box in view of higher CL grade.

The duration of intubation was more with Macintosh laryngoscope using COVID barrier box in participants

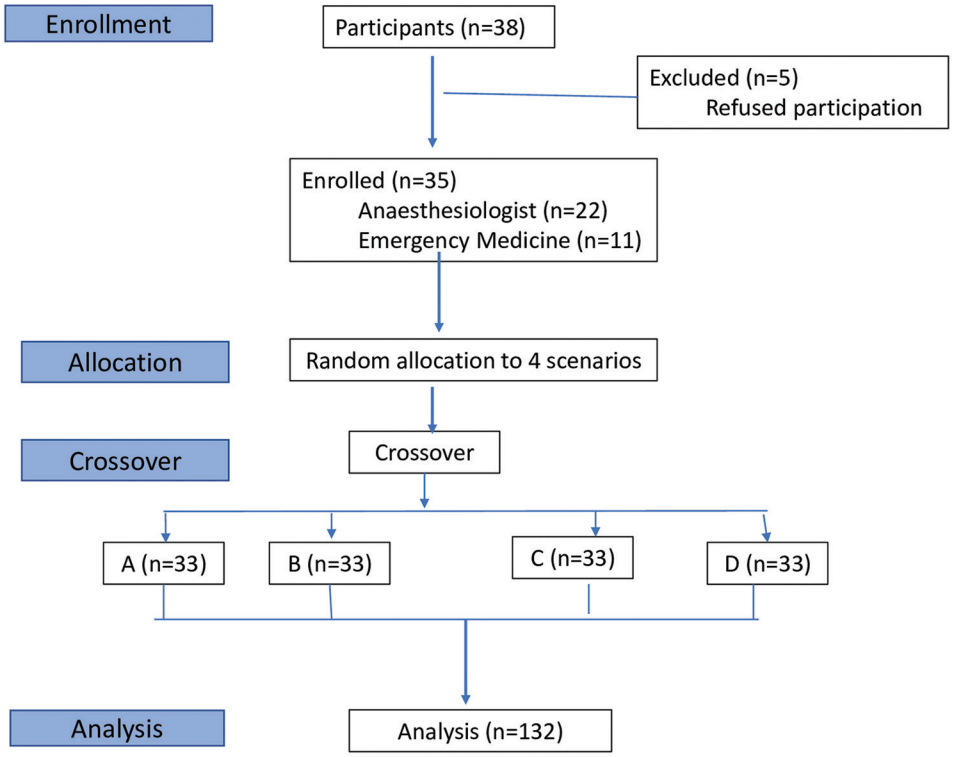

Figure 3: Consort flowchart of study participants. (a) Intubation with Macintosh laryngoscope without COVID barrier box group, (b) Intubation with Macintosh laryngoscope with COVID barrier box group, (c) Intubation with KVVL without COVID barrier box, (d) Intubation with KVVL with COVID barrier box group. COVID-19: Coronavirus disease 2019, KVVL: King Vision video laryngoscope

Table 2: Comparison of different parameters for Macintosh laryngoscope with or without coronavirus disease barrier box

Variables	With COVID barrier box, *n* (%)	Without COVID barrier box, *n* (%)	Mean difference/ OR (95% CI)
Duration (s), mean±SD*	12.89±4.28	11.82±4.25	1.07 (−0.04-2.18)
Ease of intubation			
Grade I	7 (21.2)	11 (33.3)	1 (reference)
Grade II	18 (54.5)	18 (54.5)	0.64 (0.20-2.01)
Grade III	5 (15.2)	3 (9.1)	0.38 (0.07-2.12)
Grade IV	3 (9.1)	1 (3.0)	0.21 (0.02-2.46)
CL grade			
Grade 1	14 (42.4)	13 (39.4)	1 (reference)
Grade 2	19 (57.6)	20 (60.6)	1.13 (0.43-3.03)
Number of attempts			
1	31 (93.9)	33 (100.0)	Reference
>1	2 (6.1)	0	-
ELM			
No	32 (97.0)	33 (100.0)	Reference
Yes	1 (3.0)	0	-

*95% CI for duration was calculated for mean difference. CI for number of attempts and ELM could not be calculated. CI: Confidence interval, ELM: External laryngeal manipulation, SD: Standard deviation, OR: Odds ratio, CL: Cormack-Lehane, COVID: Coronavirus disease

Table 3: Comparison of different parameters for video laryngoscope with or without coronavirus disease barrier box

	With COVID barrier box, *n* (%)	Without COVID barrier box, *n* (%)	Mean difference/ OR (95% CI)*
Duration (s), mean±SD	13.21±4.05	12.08±3.73	1.13 (−0.47-1.85)
Ease of intubation			
Grade I	7 (21.2)	7 (21.2)	Reference
Grade II	19 (57.6)	19 (57.6)	0.98 (0.29-3.41)
Grade III	6 (18.2)	6 (18.2)	0.97 (0.21-4.67)
Grade IV	1 (3.0)	1 (3.0)	0.99 (0.05-19.4)
CL grade			
Grade 1	27 (81.8)	27 (81.8)	Reference
Grade 2	6 (18.2)	6 (18.2)	0.97 (0.29-3.49)
Number of attempts			
1	32 (97.0)	33 (100.0)	Reference
>1	1 (3.0)	0	-
ELM			
No	32 (97.0)	32 (97.0)	Reference
Yes	1 (3.0)	1 (3.0)	0.99 (0.06-16.69)

*95% CI for duration was calculated for difference in mean. CI for number of attempts could not be calculated. CI: Confidence interval, ELM: External laryngeal manipulation, SD: Standard deviation, OR: Odds ratio, CL: Cormack-Lehane, COVID: Coronavirus disease

having less year of experience, but the year of experience had no correlation with KVVL.

Fong *et al*., in their randomized crossover manikin-based simulation study using the aerosol box with GlideScope, found that the aerosol box increased the intubation time by 6 s which was not statistically significant.[13] They also reported that the aerosol box could be an adjunct to personal protective equipment (PPE) to reduce the aerosol spread. Our study found that COVID-19 barrier box increased intubation time in both Macintosh laryngoscope and KVVL, but it was not statistically significant.

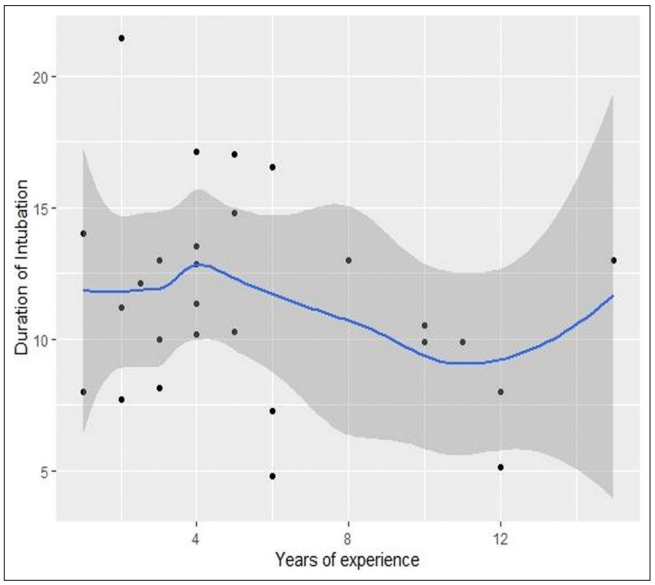

Figure 4: Correlation between duration of intubation with Macintosh laryngoscope and years of experience

Kannaujia *et al*. had done a simulation study on manikin found no significant difference in intubation time, glottic view, and the first-pass success rate with or without the aerosol box using GlideScope video laryngoscope, which was similar to our study.[14] However, the participants included in their study were senior consultant anesthesiologists, while we included both residents and consultants of both anesthesia and emergency departments, which is more generalizable.

Abolkheir *et al*. had done a manikin study, found time to intubation was more with GlideScope than Macintosh laryngoscope which was similar to our study.[15]

Our study also got similar findings to a few other studies conducted in real patients with COVID-negative status. The barrier box did not cause delay in intubation time in a non-inferiority trial comparing with and without barrier box.[16] In prospective trials by Jen *et al*. and Sahoo *et al*. in COVID-19-negative patients with normal airways, the use of the COVID-19 barrier box did not significantly delay the intubation time nor decrease the first-pass success rate.[17,18]

During this COVID era, the role of PPE was crucial for health-care providers' safety.[19] Shortage of PPE was also seen in a few places because of its extensive use during patient care. The idea of improving safety leads to the development of the barrier box.

Table 4: Comparison of different parameters for Macintosh and video laryngoscope with coronavirus disease barrier box

	Macintosh laryngoscope with COVID barrier box, *n* (%)	Video laryngoscope with COVID barrier box, *n* (%)	Mean difference/ OR (95% CI)*
Duration (s), mean±SD	12.89±4.28	13.21±4.05	−0.32 (−1.21-0.97)
Ease of intubation			
Grade I	7 (21.2)	7 (21.2)	Reference
Grade II	18 (54.5)	19 (57.6)	1.0 (0.29-3.43)
Grade III	5 (15.2)	6 (18.2)	1.2 (0.25-5.84)
Grade IV	3 (9.1)	1 (3.0)	0.33 (0.03-4.04)
CL grade			
Grade 1	14 (42.4)	27 (81.8)	Reference
Grade 2	19 (57.6)	6 (18.2)	0.17 (0.06-0.52)
Number of attempts			
1	31 (93.9)	32 (97.0)	Reference
>1	2 (6.1)	1 (3.0)	0.50 (0.04-5.80)
ELM			
No	32 (97.0)	32 (97.0)	Reference
Yes	1 (3.0)	1 (3.0)	0.97 (0.06-16.18)

*95% CI for duration was calculated for difference in mean. . CI: Confidence interval, ELM: External laryngeal manipulation, SD: Standard deviation, OR: Odds ratio, CL: Cormack-Lehane, COVID: Coronavirus disease

Limitations

Unlike Begley *et al*., we have not studied the PPE breach in our manikin study due to resource constraints.[20] We have not studied the difficult airway scenarios and the degree of aerosol spread in our study. As the study has been done in simulated environment, the results may differ in clinical scenario. However, our findings are similar to few clinical studies. All the participants have more than 1 year of experience, and findings may be different when used by novice residents during airway management. We have not studied the effect of other types of protective barriers such as hoods and tents. The results from this study may not be generalizable to other design of COVID-19 barrier box.

Conclusion

The time to intubation was more with the COVID-19 barrier box using with KVVL than Macintosh laryngoscope which was not statistically significant. Hence, both Macintosh laryngoscope and KVVL can be used for intubation with a COVID barrier box. Further randomized control trials with a larger sample size may be considered in COVID-19-positive patients to validate these data with a barrier box.

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Author contributions

SS: conceptualization; data curation; formal analysis; methodology; project administration; resources; supervision; validation; writing – review and editing. NS: data curation; investigation; methodology; visualization; writing – original draft: data curation; investigation; visualization; writing – original draft; writing – review and editing. UH: data curation; visualization; writing – original draft; writing – review and editing. CM: methodology; data curation; investigation; visualization; writing – original draft; writing – review and editing. SG: methodology; data curation; investigation; visualization; writing – original draft; writing – review and editing.

Conflicts of interest

None Declared.

Ethical approval

This protocol was approved by the Ethics Committee of AIIMS, Bhubaneswar, Odisha, India, IEC NO-T/IM-NF/T&EM/20/39 dated November 12, 2020.

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