REFLEX CIRCULATORY RESPONSES TO TRACHEAL INTUBATION PERFORMED UNDER TOPICAL ANESTHESIA * †

B. D. King, M.D., J. D. Elder, M.D., D. F. Proctor, M.D., and R. D. Dripps, M.D.

Philadelphia, Pennsylvania

Received for publication August 19, 1953

In a previously published study describing the effects of tracheal intubation upon blood pressure and heart rate (1), it was shown that direct laryngoscopy or tracheal intubation during light general anesthesia usually is capable of producing an increase in either blood pressure or heart rate or both. These responses were not due to coughing, hypoxia or hypercapnia. It was further shown that this reflex could be modified or abolished by deep general anesthesia. Similar results have since been noted by Colon-Yordan (2) during light anesthesia.

The present study was undertaken to compare the circulatory effects of introducing a laryngoscope or tracheal catheter in the fully conscious patient, utilizing topical anesthesia. In those investigations thus far reported in which topical anesthesia has been employed (3–6) the emphasis has been placed upon electrocardiographic changes produced by tracheal intubation, and simultaneous blood pressures were not obtained. These studies also differed from the present study in that topical anesthesia was usually utilized as an adjuvant for intubation performed during general anesthesia. The only data in any number which were obtained from conscious patients as in the present study were secured by Burstein (3). He noted electrocardiographic alterations in 3 of the 6 patients who were intubated while conscious following cocainization, and interpreted these changes as sequelae of sympathetic stimulation.

Method

The 21 subjects who form the basis of this study varied in age from 18 to 80 years. All were hospital patients, selected at random, who were to have subsequent surgical procedures. Blood pressure and pulse rate were obtained from a brachial artery by means of a Lilly

* From the Department of Anesthesiology, Hospital of the University of Pennsylvania, the Harrison Department of Surgical Research, University of Pennsylvania School of Medicine and the Department of Anesthesiology, Graduate School of Medicine, University of Pennsylvania.

† This investigation was supported (in part) by grants from the National Heart Institute, U. S. Public Health Service.

capacitance electromanometer (7, 8), and recorded continuously by means of a Brush direct writing oscillograph. The base line and calibration of the manometer recording were checked at frequent intervals during the determinations. All but 3 recordings were commenced before application of topical anesthesia was begun. Simultaneous electrocardiograms were obtained in 13 patients and were recorded on another channel of the oscillograph.

Endotracheal catheters were placed into the trachea under direct vision, employing oral or nasal passage of the tube in 18 patients and blind intubation through the nose in the other 3. The subjects are grouped in table 1 according to the method employed.

Surface anesthesia of the base of the tongue, pharynx, epiglottis, larynx and trachea to permit satisfactory use of the laryngoscope was obtained either by use of a modified Rowbotham atomizer (9), a type selected because of its fine spray; or by application of the anesthetic solution with cotton tipped applicators and laryngeal cannula. When nasal anesthesia was necessary, the agent was applied by atomizer or cotton applicator.

Solutions of cocaine (10 or 2 per cent) and tetracaine (2 or 0.5 per cent) were employed. The amount of solutions used was measured and the total dose of cocaine limited to 200 to 250 mg., while that of tetracaine was limited to 40 mg. When solutions were instilled intratracheally by cannula, no more than one fourth the total amount of drug was given by this route.

Atropine or scopolamine is a particularly valuable adjuvant in the application of topical anesthesia for it prevents the excessive salivation which can wash away much of the topical anesthetic. One of these agents in combination with morphine, meperidine or pentobarbital was given to all but 3 patients. To avoid any antivagal effects, the belladonna derivative was deliberately omitted from the preanesthetic medication of these 3 patients. Several additional patients were treated in a similar manner, but could not be included in this series because excessive salivation precluded satisfactory topical anesthesia for intubation in the conscious state.

One patient (case 21) was cocainized so as to permit easy laryngoscopy and visualization of the glottis without coughing, following which thiopental-decamethonium bromide anesthesia was employed for laryngoscopy and intubation.

RESULTS

The data are presented in table 1. In order to obtain representative values for systolic and diastolic blood pressure and pulse rate, multiple measurements (usually 6) secured from the continuous record at each designated interval were averaged. Since the respiratory cycle usually caused alterations in blood pressure, a maximal and minimal

TABLE 1

Case	Age and Sex	Resting		Following Topical Anesthesia		During Nasal Passage of Tube		During Laryngoscopy		After Tracheal Intubation		
										Sustained		Peak
		Pulse Rate	Blood Pressure	Pulse Rate	Blood Pressure	Pulse Rate	Blood Pressure	Pulse Rate	Blood Pressure	Pulse Rate	Blood Pressure	Blood Pressure
1 M. W.	51 F	80	155/75	90	180/77	84	169/70			124	203/103	252/122
2 C. K.	23 M	—	—	100	122/87	82	124/86			150	126/86	136/86
3 P. M.	36 M	—	—	114	152/106	110	164/108			170	188/135	270/175
4 R. P.	80 M	72	132/58	83	125/56	72	132/57	108	147/82	113	178/82	215+/110
5 D. M.	26 F	102	118/65	118	120/73	148	120/67	162	148/91	162	133/76	175/75
6 D. P.	23 F	72	122/79	101	133/82	83	140/85	124	146/84	167	146/91	215+/150
7 M. C.	48 F	75	160/100	70	177/98	81	169/93	76	171/94	101	215/113	238/130
8 E. C.*‡	48 M	80	125/75	100	129/82	80	143/82	102	130/84	104	118/76	122/80
9 E. J.*‡	67 F	74	211/98	81	253/121			92	278/138	98	295/148	305/133
10 J. J.†‡	32 F	65	132/80	79	145/83			100	172/107	108	164/90	170/94
11 A. N.†	30 F	112	149/82	140	187/99			138	200/102	140	206/108	230/119
12 E. S.	60 F	90	187/88	115	203/100			130	200/102	132	272/149	350/190
13 R. M.	35 F	91	112/73	120	128/81			125	142/100	150	167/99	215/157
14 A. G.	50 F	134	169/104	150	208/105			156	229/112	172	294/191	340+/226
15 R. M.	32 F	95	145/91	96	144/84			93	141/81	108	188/113	204/118
16 J. F.	26 M	—	—	146	176/112			150	185/112	170	177/115	270/180
17 S. M.	18 M	114	147/84	132	152/92			140	158/98	156	168/100	198/134
18 R. W.	23 M	81	103/72	82	136/89			98	125/80	110	117/72	150/60
19 R. S.	41 F	168	128/80	188	151/92			195	180/119	200	180/111	234/156
20 J. D.	25 M	70	105/68	72	129/81			104	139/100	108	167/107	182/125
21 W. O.	19 M	100	136/81	104	128/82			80	161/100	—	—	—
W. O.§		85	130/88	—	—			92	142/96	118	175/124	—

* Cocaine by applicator
† Tetracaine by applicator } all others had cocaine spray.
‡ Received no atropine or scopolamine.
§ Following the administration of thiopental-decamethonium bromide.

blood pressure were always paired and included in this average to take respiratory variations into account.

Effect of Topical Anesthesia: Data were secured on 18 patients. No signs of toxicity from the topical anesthetic were noted with the possible exception of case 10 who exhibited tremors during the tracheal instillation of tetracaine. These tremors rapidly subsided. Pulse rate increased in 17 of the 18 patients an average of 13.7 beats per minute ($P < 0.01$). Systolic pressure increased an average of 16.2 mm. of mercury, also a significant change ($P < 0.01$).

Insertion of Tube in the Nose: In 8 patients the tube was inserted nasally. Six showed a decrease in pulse rate, 2 an increase. The average decrease was 4.4 beats per minute. Systolic blood pressure increased in 5 and decreased in 2, the average increase being 2.4 mm. of mercury. None of these changes are statistically significant.

Laryngoscopy: Of the 18 patients who were laryngoscoped during topical anesthesia, 14 showed an increase in pulse rate and 15 an increase in systolic blood pressure. Pulse rate increased an average of 10.9 beats per minute ($P < 0.01$) and systolic blood pressure an average of 12.7 mm. of mercury ($P < 0.01$).

Tracheal Intubation: The "sustained" pulse rate and blood pressure after intubation were recorded during the maximal reflex effect of intubation upon circulation, and peaks due to coughing were excluded from the average.

Insertion of the tube into the trachea caused an average increase in pulse rate of 17.6 beats per minute ($P < 0.01$) and of systolic blood pressure of 17.7 mm. of mercury ($P < 0.01$). Blood pressure and pulse rate remained above the levels obtained before laryngoscopy for one to four minutes in most instances; the pulse rate usually remained elevated for a slightly longer period than did the blood pressure.

The value for peak blood pressure after tracheal intubation is not an average, but is the maximal blood pressure attained after intubation whether as a result of instrumentation or cough. In the 17 patients on which such data are available, the average increase of systolic blood pressure over the resting blood pressure level was 82 mm. of mercury. Such peaks were usually sustained for only several cardiac cycles. Four patients (cases 12, 13, 14 and 19) had peak systolic pressure levels which were 163, 103, 171 and 106 mm. of mercury, respectively, above resting levels.

Alterations in Cardiac Rhythm: Instrumentation and intubation caused no discernible cardiac arrhythmias on the continuous arterial blood pressure tracings of the 8 patients on whom only pulse pressures were obtained, although extra systoles are usually readily identified in such a record. In one of the patients (case 3), who exhibited frequently recurrent premature ventricular contractions, cardiac rhythm was converted to a regular rhythm for several minutes following entrance of the tube into the trachea.

Among the remaining 13 patients on whom electrocardiograms were obtained there were a few premature ventricular contractions, occurring upon laryngoscopy in 2 patients (cases 6 and 12) and following intubation in 3 (cases 9, 11 and 12). Case 9 also experienced several premature auricular contractions.

No other arrhythmias were observed. For comparative purposes it may be noted that premature ventricular contractions are among the most common arrhythmias occurring during intubation under general anesthesia (1, 2, 3).

Cocainization and Thiopental-Decamethonium Anesthesia: Laryngoscopy and intubation following a combination of general anesthesia preceded by adequate topical anesthesia (case 21) resulted in circulatory alterations similar to those encountered under *either* topical anesthesia *or* light general anesthesia alone. Since the pattern of response is the same under topical and under light general anesthesia separately, the result obtained in this patient might be anticipated. A larger number of individuals treated in this manner would probably serve only to indicate to what degree the magnitude of the changes in blood pressure and pulse rate might be modified by combining topical and general anesthesia.

DISCUSSION

The application of topical anesthesia to the upper respiratory tract can result in a significant rise in systolic blood pressure and pulse rate. Presumably, the most important element in this response is the effect of systemically absorbed anesthetic agent upon the cardiovascular system. Cocaine is believed to stimulate the sympathetic nervous system (10); a similar effect was noted in the 2 patients receiving tetracaine. The importance of excitement attendant upon a new experience cannot be determined; however, this factor appears to be minor. A third factor of perhaps some importance is the coughing which was engendered by intratracheal spray or instillation of the topical anesthetic. A short bout of coughing would have a sustained effect only upon pulse rate; that reaction, however, would have been dissipated in large part by the time this portion of the recording was made, since the patients had been resting quietly for at least several minutes.

The consequences of the application of topical anesthesia are the more striking when the relatively small amount of drug employed is considered. It has been our experience that a larger quantity of drug than estimated is dispensed if the conventional coarse atomizer with a large reservoir is used. The importance of fine atomization has been emphasized by various authors (11, 12). Other than reducing the amount of drug used, the fine atomizer has the advantage of producing more uniform anesthesia.

The rise in pulse rate and blood pressure usually accompanying laryngoscopy and tracheal intubation under topical anesthesia is simi-

lar qualitatively to that produced by the same maneuvers during light general anesthesia (1, 2). In the conscious patient this result was noted whether or not a cough accompanied these procedures. In both the conscious and the anesthetized patient the reflex would appear to be the same; pressure or traction as the sensory stimulus which evokes a response primarily from the sympathetic nervous system. There is reason to believe that the sympathetic stimulating effect of cocaine might enhance this reaction. Use of other drugs for topical anesthesia which do not possess this property might lessen the response, but qualitatively a similar effect would be expected.

Atropine or scopolamine was deliberately omitted from the preanesthetic medication of 3 patients in order to observe whether such drugs were masking evidence of increased vagal activity. Pulse rate in these patients responded to instrumentation in a manner similar to the rest of the group.

The only maneuver which caused a slowing of the pulse rate was passage of the tube through the nose, a result not elicited in every instance. Since the response was not uniform in the small group intubated nasally, the mean decrease in pulse rate is not significant. It would appear that stimulation of the trigeminal nerve in the nose is capable of producing cardiac slowing. Such an effect has been observed in a patient under light general anesthesia (1).

Coughing could not be avoided completely in many of the individuals studied. In most instances it was minimal; only 3 patients coughed more than five or six times after insertion of the tube into the trachea. Part of the rise in blood pressure and pulse rate which occurred following tracheal intubation may be attributed to this influence in many instances. The peaks in pressure which were associated with such coughs were occasionally quite striking. Two patients (cases 12 and 14) had peaks of systolic pressure over 340 mm. of mercury despite the fact that presence of the tube prevented closure of the glottis. The importance of these sharp elevations in pressure cannot be fully ascertained. Such increases in pressure might conceivably be encountered in daily life. Hamilton (13) has shown that the cerebrospinal fluid pressure rises *pari passu* with a cough, so that damage to blood vessels in the brain is less likely. Pressure overshoots as seen following the Valsalva maneuver and straining (13) might be dangerous (14), but were not observed in these patients. In patients under general anesthesia, long bouts of coughing have been observed to cause tachycardia and ultimate depression of pulse pressure; this was not noted in the present series, probably because of the short duration of any coughing that did occur.

Arrhythmias occurring during intubation were not frequent, serious, or of long duration. The majority of these disturbances were premature ventricular contractions. If the anesthesiologist is concerned

about the possibility of such arrhythmias, a drug that does not stimulate the sympathetic nervous system should probably be chosen to produce topical anesthesia. It seems logical that the best prophylaxis, particularly if cocaine is employed, would be to use only small, measured amounts of the agent. It should be noted that intubation can also produce a temporary reversion to normal rhythm (case 3). A cough also may be sufficient stimulus to terminate an arrhythmia; this has been observed in the intubated patient during general anesthesia.

Topical anesthesia is often applied to the throat, larynx and trachea to mitigate circulatory reflexes which might occur in the course of tracheal intubation during general anesthesia. Often the application of such drugs is entirely too cursory to provide adequate surface anesthesia, and no beneficial effects could accrue from such a procedure. Burstein (3) has shown a high incidence of cardiac arrhythmias despite cocainization; the use of hexylcaine (5), a drug with a procainelike action on the heart, decreased the incidence of cardiac arrhythmias when used for topical anesthesia. In the present study it has been shown that cocainization of the larynx and trachea adequate to perform smooth laryngoscopy in a conscious patient will not prevent the usual effects upon blood pressure and pulse rate from intubation during light general anesthesia (thiopental and decamethonium bromide).

The relative importance of reflex circulatory responses in the conscious and anesthetized patient cannot be ascertained, by us, at the present time. However, it is most important that we do know what effects may be expected so that any untoward reactions during intubation may be better evaluated. The pressor effect (1, 2), increased pulse rate (1, 3) and arrythmias (1, 3, 6) which have been described probably would be innocuous to the normal circulatory system. Perhaps some injury might ensue in the patient with severe cardiovascular disease. One of our patients (#11), being anesthetized for a mitral commissurotomy had a rather marked pressor response and premature ventricular contractions following intubation, despite the fact that there was no coughing. In this patient, as well as in the others, there was no subsequent evidence of deleterious effects from the procedure. This, of course, does not exclude the possibility of some injury having occurred.

The most logical attitude toward these circulatory reflexes is one of moderation. Undoubtedly, means should be found to minimize them. However, overzealous use of deep general anesthesia, topical anesthesia, or cardiac depressant drugs in an attempt to prevent reflex circulatory alterations caused by intubation ultimately may be more detrimental to the patient than the condition that was to be avoided. The physician must never lose sight of the simple fact that catastrophes at the time of intubation are more likely to ensue from anoxia, overanesthetization or reactions to topical anesthetics than from circulatory reflexes incurred by facile intubation.

SUMMARY

The circulatory alterations produced by topical anesthesia, laryngoscopy and intubation in the conscious patient have been studied by observation of the changes in blood pressure and cardiac rate and rhythm.

The application of topical anesthesia was followed by an increase in blood pressure and pulse rate in most instances. Laryngoscopy and intubation likewise caused a rise in blood pressure and cardiac rate but, in addition, occasionally produced transient cardiac arrhythmias. These responses to instrumentation are similar qualitatively to those occurring during light general anesthesia.

The possible importance of these circulatory changes produced by reflex activity and coughing has been discussed.

REFERENCES

1. King, B. D., *et al.*: Reflex Circulatory Responses to Direct Laryngoscopy and Tracheal Intubation Performed During General Anesthesia, Anesthesiology 12: 556–566 (Sept.) 1951.
2. Colon-Yordan, E.: Mackrell, T. N., and Stone, H. H.: An Evaluation of Use of Thiopental and Decamethonium Bromide for Rapid Endotracheal Intubation, Anesthesiology 14: 255–277 (May) 1953.
3. Burstein, C. L.; LoPinto, F. J., and Newman, W.: Electrocardiographic Studies During Endotracheal Intubation, Effects During Usual Routine Technics, Anesthesiology 11: 224–237 (March) 1950.
4. Burstein, C. L.; Woloshin, G., and Newman, W.: Electrocardiographic Studies During Endotracheal Intubation, Effects During General Anesthesia and Intravenous Procaine, Anesthesiology 11: 299–312 (May) 1950.
5. Areuri, R. A.; Newman, W., and Burstein, C. L.: Electrocardiographic Studies During Endotracheal Intubation, Effects During General Anesthesia and Hexylcaine Hydrochloride Topical Spray, Anesthesiology 14: 46–52 (Jan.) 1953.
6. Converse, J. G.; Landmesser, C. M., and Harmel, M. H.: Electrocardiographic Changes During Extubation. A Study of Electrocardiographic Patterns During Endotracheal Anesthesia Including Those Seen During Intubation, Endotracheal Suction and Particularly Extubation, Anesthesiology 13: 163–168 (March) 1952.
7. Lilly, J. C.; Legallais, V., and Cherry, R.: Variable Capacitor for Measurements of Pressure and Mechanical Displacements; Theoretical Analysis and Its Experimental Evaluation, J. Appl. Physics 18: 613–628 (July) 1947.
8. Peterson, L. H.; Dripps, R. D., and Risman, G. C.: Method for Recording Arterial Pressure Pulse and Blood Pressure in Man, Am. Heart J. 37: 771–782 (April) 1949.
9. Rowbotham, Stanley: Anesthesia in Operations for Goitre, Springfield, Ill., Charles C Thomas, 1947, p. 67.
10. Goodman, Louis, and Gilman, Alfred: The Pharmacological Basis of Therapeutics, New York, The Macmillan Company, 1941, p. 294.
11. Macintosh, R. R.: Technique of Laryngeal Anesthesia, Lancet 2: 54–55 (July 12) 1947.
12. Carabelli, A. A.: Use of Pontocaine in Subposologic Quantities for Bronchoscopy and Bronchography, Anesthesiology 13: 169–183 (March) 1952.
13. Hamilton, W. F.; Woodbury, R. A., and Harper, H. T., Jr.: Arterial, Cerebrospinal and Venous Pressures in Man During Cough and Strain, Am. J. Physiol. 141: 42–50 (March) 1944.
14. McGuire, J., *et al.*: Bed Pan Deaths, Am. Pract. and Digest Treat. 1: 23–28 (Jan.) 1950.