Original Article

Spontaneous Breathing Trial with Pressure Support Ventilation and Outcome of Extubation

Dr. Mohammad Salim[1], Dr. Mohammad Mohsin[2], Dr. Subroto Kumar Sarker[3], Dr Jannat Ara Rumana[4], Dr A K M Ferdous Rahman[5], Dr. Md Mozaffer Hossain[6]

[1]Assistant Professor (Critical Care Medicine), Department of Anaesthesia, Analgesia, Palliative & Intensive Care Medicine, Dhaka Medical College, Dhaka, Bangladesh; [2]Assistant Professor (Critical Care Medicine), Department of Anaesthesia, Analgesia, Palliative & Intensive Care Medicine, Dhaka Medical College, Dhaka, Bangladesh; [3]Assistant Professor (Critical Care Medicine), Department of Anaesthesia, Analgesia, Palliative & Intensive Care Medicine, Dhaka Medical College, Dhaka, Bangladesh; [4]Medical Officer (Gynae Oncology), National Institute of Cancer Research & Hospital, Dhaka, Bangladesh; [5]Assistant Professor (Anasthesia), Department of Aneasthesia, Analgesia, Palliative & Intensive Care Medicine, Dhaka Medical College, Dhaka, Bangladesh; [6]Professor & Head, Department of Anaesthesia, Analgesia, Palliative & Intensive Care Medicine, Dhaka Medical College, Dhaka, Bangladesh.

Corresponding Author: Dr.Mohammad Salim E-mail: salimdr57@gmail.com

Abstract

Background: *Failure to wean causes prolonged ICU stay, increases complications associated with mechanical ventilation and increases morbidity and mortality. Spontaneous breathing trial (SBT) is the final step of weaning before extubation.*

Objective: *To observe the efficacy of pressure support ventilation (PSV)method of spontaneous breathing trial(SBT) for successful extubation.*

Methods: *This prospective observational study was carried out in the Department of Anesthesia, Analgesia, Palliative and Intensive Care Medicine, Dhaka Medical College & Hospital from January 2015 to December 2016. A total of 116 patients on ventilator who were ready for spontaneous breathing trial, were enrolled in this study. Patients were divided randomly into two groups. Among them, 58 patients underwent SBT using PSV and remaining 58 patients underwent SBT using T-piece.*

Result: *Mean duration of SBT among SBT failure patients was higher in PSV group than T-piece group (107.1±16.0 vs 85.0±25.0). Among the patients successfully completing SBT, re-intubation was required in 15.2% cases and 17.6% cases in T-piece and PSV group respectively. 67.2% patients in T-piece group and 72.4% patients in PSV group were successfully extubated, extubation failure occurred in 12.1% and 15.5% cases in T-piece and PSV group respectively and SBT failure occurred in 20.7% and 12.1% cases in T-piece and PSV groups respectively.*

Conclusion: *Tolerance of the SBT and successful extubation were high in both groups but relatively higher in PSV group. Reintubation rate was almost same in both groups. None of these findings were statistically significant.*

Key words: *Spontaneous Breathing Trial, Pressure Support Ventilation, Extubation.*

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Introduction

Endotracheal intubation and mechanical ventilation (MV) are two separate, distinct processes that occur together in critical care unit in order to be useful. Endotracheal intubation and mechanical ventilation are the most frequently performed and most costly interventions in intensive care units to support the respiratory function.[1-2] MV is an invasive procedure and is associated with many serious complications, adverse physiological and psychological experiences.[3-4] The complications include injury to the vocal cords, trachea or larynx, tracheal stenosis, haemoptysis, ventilator-associated pneumonia (VAP), increased need for sedation, increased gastro-intestinal stress, skin breakdown and decubitus ulcers, muscle wasting, muscle weakness and pulmonary barotrauma.[1,5-6] VAP is by far the most serious complication of MVand is often due to increased number of days of MV and the intubation procedure itself.[7-9] The incidence of unplanned extubation ranges 0.3–16%.[10] In most cases (83%), the unplanned extubation is initiated by the patient, while 17% are accidental.[10] Almost half of patients with self-extubation during the weaning period do not require reintubation, suggesting that many patients are maintained on mechanical ventilation longer than is necessary.[11] Increase in the extubation delay between readiness day and effective extubation significantly increases mortality. In the study by Coplin et al.[12], mortality was 12% if there was no delay in extubation and 27% when extubation was delayed. So To minimize these risks and complications, it is important that patients be weaned and extubated from MV at the earliest possible time.[4-5,13-16]Weaning from mechanical ventilation is a 2-step process. First, objective criteria are used to determine whether sufficient recovery from acute respiratory failure has occurred to allow the patient to breathe independently. This “readiness test” is followed by a spontaneous breathing trial (SBT) which is the recommended and widely usedfinal test to assess whether the patient can breathe spontaneously or still requires mechanical ventilatory support.[14,17-18] Passing the SBT is interpreted as readiness for discontinuation of ventilator support, whereas failing the SBT indicates non-readiness.There has been considerable interest in determining the best approach for conducting the SBT and how long it should be. The ideal SBT would accurately mimic the work of breathing (WOB) done without ventilatory support and without the ETT in place. A T-piece trial of spontaneous breathing lasting 2 hours is a useful test in selecting patients who are ready for extubation.[19-21] Such a trial is associated with a rate of extubation failures, ranging from 15 to 19%. The increase in the work of breathing caused by the presence of an endotracheal tube may be an excessive load for some patients breathing through the T-piece circuit and poor tolerance of the trial can result from this. Pressure support ventilation is useful to overcome the resistance of the ETT and may enable patients to meet the weaning criteria even if they would not pass a T-piece SBT.[16,22,23] In general, the level of pressure support necessary to decrease the work of breathing to that after extubation is 7 to 8 cm H_2O.[24-26] Another important feature of pressure support ventilation is that it improves the efficacy of spontaneous breathing and reduces external respiratory work and oxygen consumption by respiratory muscles during weaning.[27-30] Unfortunately, it is challenging to predict the exact PSV level required to overcome this imposed WOB in a given patient. The purpose of this study was to investigate the efficacy of pressure support ventilation method of spontaneous breathing trial for successful extubation in patients with mechanical ventilation for more than 48 hours. This study may help physicians to take prompt decision about extubating the patients from mechanical ventilation.Aim of this study wasto observe efficacy of pressure support ventilation (PSV) method of spontaneous breathing trial for successful extubation.

Methodology & Materials

This prospective observational study was conducted in the Department of Anesthesia, Analgesia, Palliative & Intensive Care Medicine, Dhaka Medical College & Hospital, Dhaka, Bangladesh from January, 2015 to December, 2016. After considering inclusion and exclusion criteria, a total of 116 patients on ventilator who were ready for spontaneous breathing trial, were enrolled in this study. Patients were divided randomly into two groups. Written consent was taken from patient's guardian regarding this study. Among them58 patients underwent SBT using PSV and remaining 58 patients on T-piece. Vital parameters were recorded at the baseline and then throughout the SBT. Outcome of SBT was recorded as SBT failure, successful extubation and extubation failure. Then these were compared between two groups.Statistical analyses were carried out by using the Statistical Package for Social Sciences version 22.0 for Windows (SPSS Inc., Chicago, Illinois, USA). The mean values were calculated for continuous variables. The qualitative observations were expressed by frequencies and percentages. Chi-Square test was used to analyze the categorical variables. Student Unpaired t-test was used for continuous variables such as age, RSBI etc. P value <0.05 was considered as statistically significant.

Inclusion criteria:

Patients of 18-50 years.

Patients of mechanical ventilation for more than 48 hours but up to 7 days.

Patients fulfilling the criteria of SBT.

Exclusion criteria:

Patients with MV lasting <48 hours or >7 days.
Patients with unplanned or accidental extubation.
Patients with spinal cord injury.
Patients with tracheostomy.
Patients with relapsing and remitting diseases like myasthenia gravis.
Patient or attendant not agreeing to participate in the study.

Result

It was conducted among 116 patients on ventilator who were ready for spontaneous breathing trial. They were divided randomly into two groups, in which 58 patients underwent SBT using PSV and remaining 58 patients on T-piece. Table I shows distribution of patients by demographic characteristics and diagnosis. On age consideration, in T piece group,majority (36.2%) patients belonged to age 21-30 years and 43.1% patients belonged to age 41-50 years in PSV group. There was no statistically significant difference (p>0.05) in age between two groups.It was observed that male was predominant in both groups butthere was no statistically significant difference (p>0.05) by gender between two groups.Post laparotomy cases were predominant in both groups, 22.4% and 20.7% inT-piece and PSV group respectively. There was no statistically significant difference (p>0.05) in diagnosis between two groups.Table II showsmean duration of mechanical ventilation was highest in extubation failure patients, 148.6±14.3 hours in T-piece group and 141.0±12.9 hours in PSV group which was followed by SBT failure and successfully extubated patients in both groups. There were no significant differences (p>0.05) in duration of mechanical ventilation between two methods in different outcome.

Table III shows that RSBI of patient with SBT failure, the successfully extubated patients and extubation failure patients at different follow up.Patient with SBT failure,RSBIrapidly increased in both methods. Before entering into SBT, mean RSBI was 50.1±4.0 in T-piece group and 51.0±3.2 in PSV group and at the end of trial, mean RSBI was 131.0±1.6 in T-piece group and 123.3±9.1 in PSV group. There was no significant difference (p>0.05) between two methods at different follow up.RSBI of the successfully extubated patientsgradually increased in both methods. Before entering into SBT, mean RSBI was 51.1±6.2 in T-piece group and 49.0±3.8 in PSV group and at the end of trial, mean RSBI was 60.0±7.2 in T-piece group

and 57.7±4.0 in PSV group but there was no significant difference (p>0.05) between two methods at different follow up.RSBI of the extubation failure patients gradually increased in both methods. Before entering into SBT, mean RSBI was 46.7±4.3 in T-piece group and 46.9±4.7 in PSV group and at the end of trial, mean RSBI was 60.5±4.3 in T-piece group and 65.3±5.4 in PSV group. There was no significant difference (p>0.05) between two methods at different follow up.

As shown in table IV, PaO_2/FiO_2 ratio of the SBT failure patients, successfully extubated patients and extubation failure patients at different follow up.PaO_2/FiO_2 reduced rapidly in both methods at the end of the trial in SBT failure group. Before entering into SBT, mean PaO_2/FiO_2 ratio was 246.9±11.1 in T-piece group and 247.4±16.1 in PSV group and at the end of trial, mean PaO_2/FiO_2 ratio was 180.3±6.7 in T-piece group and 180.7±16.5 in PSV group. There was no significant difference (P>0.05) between two methods at different follow up.PaO_2/FiO_2ratio of successfully extubated patients reduced slightly in both methods at 120 minutes. Before entering into SBT, mean PaO_2/FiO_2 ratio was 294.6±22.4 in T-piece group and 294.0±17.4 in PSV group and at the end of trial, mean PaO_2/FiO_2 ratio was 284.5±22.1 in T-piece group and 287.5±12.5 in PSV group but there was no significant difference (p>0.05) between two methods.PaO_2/FiO_2ratio of the extubation failure patients reduced slightly in both methods at 120 minutes. Before entering into SBT, mean PaO_2/FiO_2 ratio was 286.6±17.0 in T-piece group and 280.6±22.4 in PSV group and at the end of trial, mean PaO_2/FiO_2 ratio was 265.6±8.1 in T-piece group and 260.1±22.6 in PSV group but there was no significant difference (p>0.05) between two methods at different follow up.

There was no significant difference (P>0.05) by SBT failure in T-piece group and in PSV group, shown in table V. Table VI shows that mean duration of SBT (among SBT failure patients) was higher in PSV group than T-piece group (107.1±16.0 vs 85.0±25.0) but there was no significant difference (p>0.05) between these two groups.

15.2% patients and 17.6% patients neededre-intubation in T-piece group and PSV group respectively that was shown in table VII. There was no significant difference (p>0.05) between two methods.Most common cause of re-intubation was respiratory failurewhich was 42.9% and 33.3% in T-piece group andPSV group. There was no significant difference (p>0.05) between two methods.Table VIII shows that67.2% patients had successful extubation, 12.1% patients had extubation failure and 20.7% patients had SBT failure. In PSV group, 72.4% patients had successful extubation, 15.5% patients had extubation failure and 12.1% patients had SBT failure.There was no significant difference (p>0.05) between these two groups.

Table-I: Demographic characteristics and diagnosisof the study people (n=116)

Characteristics		Group		P value
		T-Tube	PSV	
		f(%)	f(%)	
Age (Years)	11 - 20	2 (3.4)	5 (8.6)	
	21 – 30	21 (36.2)	17 (29.3)	
	31 – 40	15 (25.9)	11 (19.0)	
	41 - 50	20 (34.5)	25 (43.1)	
	Mean ± SD	34.7 ± 9.5	35.1 ± 10.5	0.810 ns
	Range (min-max)	19 - 50	18 - 50	
Gender	Male	41 (70.7)	46 (79.3)	0.284 ns
	Female	17 (29.3)	12 (20.7)	
Diagnosis	Post Laparotomy	13 (22.4)	12 (20.7)	0.844 ns
	Post operative head injury	9 (15.5)	8 (13.8)	
	Head injury not operated	5 (8.6)	7 (12.1)	
	Poly trauma	2 (3.4)	4 (6.9)	
	Acute stroke	4 (6.9)	4 (6.9)	
	Eclampsia with HELLP	6 (10.3)	5 (8.6)	
	GBS	8 (13.8)	7 (12.1)	
	Sepsis	4 (6.9)	3 (5.2)	
	Meningo encephalitis	4 (6.9)	1 (1.7)	
	Pneumonia	1 (1.7)	1 (1.7)	
	Acute Bronchial asthma	0 (0.0)	2 (3.4)	
	Acute exacerbation of COPD	0 (0.0)	2 (3.4)	
	OPC poisoning	2 (3.4)	2 (3.4)	

Table II: Mean duration of mechanical ventilation in a different outcome in different methods (n=116)

Outcome	Duration of mechanical ventilation (hours)		P-value
	T-piece (Mean ± SD)	PSV (Mean ± SD)	
Successful extubation	112.9 ± 30.6	117.1 ± 20.1	0.460 ns
Extubation failure	148.6 ± 14.3	141.0 ± 12.9	0.285 ns
SBT failure	127.7 ± 16.8	130.4 ± 21.8	0.760 ns

Table-III: RSBI of the SBT failure patients, successfully extubated patients and extubation failure patients at different follow-up

Follow up		RSBI (breath/min/L)		P value
		T-piece (Mean ± SD)	PSV (Mean ± SD)	
SBT failure patients (n=19)	Baseline	50.1 ± 4.0	51.0 ± 3.2	0.622 ns
	At 30 minutes	80.2 ± 13.4	69.0 ± 5.2	0.051 ns
	At 60 minutes	100.4 ± 15.4	90.8 ± 8.0	0.148 ns
	At 90 minutes	118.9 ± 18.1	106.8 ± 11.6	0.146 ns
	At 120 minutes	131.0 ± 1.6	123.3 ± 9.1	0.327 ns
Successfully extubated patients (n=81)	Baseline	51.1 ± 6.2	49.0 ± 3.8	0.057 ns
	At 30 minutes	54.5 ± 7.6	52.0 ± 3.9	0.055 ns
	At 60 minutes	55.6 ± 7.2	53.1 ± 4.1	0.063 ns
	At 90 minutes	57.6 ± 8.1	54.6 ± 6.3	0.067 ns
	At 120 minutes	60.0 ± 7.2	57.7 ± 4.0	0.085 ns
Extubation failure patients (n=16)	Baseline	46.7 ± 4.3	46.9 ± 4.7	0.955 ns
	At 30 minutes	51.0 ± 4.1	52.1 ± 4.3	0.634 ns
	At 60 minutes	53.6 ± 4.8	56.5 ± 5.1	0.267 ns
	At 90 minutes	55.0 ± 3.7	57.7 ± 5.3	0.259 ns
	At 120 minutes	60.5 ± 4.3	65.3 ± 5.4	0.285 ns

Table-IV:PaO_2/FiO_2 ratio of the SBT failure patients, successfully extubated patients and extubation failure patients at different follow up

Follow up		PaO_2/FiO_2 ratio		P value
		T-piece (Mean ± SD)	PSV (Mean ± SD)	
SBT failure patients (n=19)	Baseline	246.9 ± 11.1	247.4 ± 16.1	0.935 ns
	At the end of the trial	180.3 ± 6.7	180.7 ± 16.5	0.937 ns
Successfully extubated patients (n=81)	Baseline	294.6 ± 22.4	294.0 ± 17.4	0.886 ns
	At 120 minutes	284.5 ± 22.1	287.5 ± 12.5	0.441 ns
Extubation failure patients (n=16)	Baseline	286.6 ± 17.0	280.6 ± 22.4	0.565 ns
	At 120 minutes	265.6 ± 8.1	260.1 ± 22.6	0.555 ns

Table V: Distribution of patients by SBT failure in groups (n=116)

SBT failure	Group		P value
	T-piece f (%)	PSV f (%)	
Yes	12 (20.7)	7 (12.1)	0.210 ns
No	46 (79.3)	51 (87.9)	

Table-VI: Duration of SBT among SBT failure patients (n=19)

	Group		P value
	T-piece (Mean ± SD)	PSV (Mean ± SD)	
Duration of SBT	85.0 ± 25.0	107.1 ± 16.0	0.052 ns

Table-VII: Distribution of patients by re-intubation requirement and by causes of re-intubation in groups

Characteristics		Group		P value
		T-piece f(%)	PSV f(%)	
Re-intubation (n=97)	Required	7 (15.2)	9 (17.6)	0.747 ns
	Not required	39 (84.8)	42 (82.4)	
Causes of re-intubation (n=16)	Upper airway obstruction	1 (14.3)	2 (22.2)	0.344 ns
	Respiratory failure	3 (42.9)	3 (33.3)	
	Decrease consciousness level	2 (28.6)	0 (0.0)	
	Excess lung secretion/inability to protect airway	1 (14.3)	2 (22.2)	
	Bronchospasm	0 (0.0)	2 (22.2)	

Table VIII: Distribution of patients by outcome of SBT in groups (n=116)

Outcome	Group		P value
	T-piece f(%)	PSV f(%)	
Successful extubation	39 (67.2)	42 (72.4)	0.543 ns
Extubation failure	7 (12.1)	9 (15.5)	0.590 ns
SBT failure	12 (20.7)	7 (12.1)	0.210 ns

Discussion

A spontaneous breathing trial assesses the patient's ability to breathe while receiving minimal or no ventilator support.In this present study, it was observed that the majority of patients belonged to 3rd decade in the T-piece group (36.2%) and 5th decade in the PSV group (43.1%). The mean age was found 34.7±9.5 years with a range from 19 to 50 years in T-piece group and 35.1±10.5 years with a range from 18 to 50 years in the PSV group. Teixeira et al.[31] showed mean age was 46.8±20.8 years and 44.3±19.8 years in the T-piece group and PSV group respectively. Brochard et al.[20] showed mean age was 54.5±17.5 years and 62.9±15.9 years in the T-piece group and PSV group respectively and Esteban et al.[19] found mean age was 59.1±16.4 years and 59.9±16.4 years in the T-piece group and PSV group respectively, which all are higher than the current study. The higher mean age obtained by the above authors may be due to geographical variations, racial, ethnic differences, genetic causes, different lifestyles, and increased life expectancy may have a significant influence on their study patients.This study showed that males were predominant in both groups. Esteban et al.[22] found male was 68% in the T-piece group and 74% in the PSV group, which is consistent with the current study. Similarly, Teixeira et al.[31]and Matic et al.[32] also found male was predominant in both groups.

Regarding diagnosis of the patients, while being admitted in ICU,the most common diagnosis was post laparotomy followed by postoperative head injury and GBS. Teixeira et al.[31] found the most common diagnosis on ICU admission as traumatic brain injury followed by post-operative cases and trauma without brain injury. Matic et al.[32] found the most common diagnosis on ICU admission as polytrauma followed by postoperative state and others. Esteban et al.[22] found the most common diagnosis on ICU admission as postoperative state followed by pneumonia and heart failure. All the above-mentioned study's findings are comparable with the current study.

Mean duration of mechanical ventilation was highest in extubation failure patients followed by SBT failure and successfully extubated patients in both groups. Esteban et al.[22] found median duration of mechanical ventilation of 6 days in both groups with range from 4-9 days for T-piece group and 4-12 days for PSV group which showed no significant difference which is consistent with current study. Brochard et al.[20] found mean duration of mechanical ventilation of 17±31 days for T-piece group and 14±17 days for PSV group which showed no significant difference. Here duration of mechanical ventilation was much higher than current study.

Esteban et al.[19]found mean duration of mechanical ventilation of 8.4±5.3 days for T-piece group and 10.8±8.6 days for PSV group which showed no significant difference. Teixeira et al.[31] found mean duration of mechanical ventilation of 7.1±4.1 days for T-piece group and 6.6±4.4 days for PSV group. So most of the studies support current study in the fact that there are no significant differences in length of mechanical ventilation time to successful extubation when comparing T-piece and pressure support ventilation.

After discontinuation of ventilation support, RSBI increased rapidly and PaO_2/FiO_2 ratio decreased rapidly in SBT failure patients in both methods but changed a little in successfully extubated and extubation failure patients. Esteban et al.[22] also had similar findings. Mean duration of SBT among SBT failure patients was higher in PSV group than T-piece group but there was no significant difference between these two methods. Matic et al.[32] found median duration of SBT among SBT failure patient was 42 minutes in T-piece group and 37 minutes in PSV group which is lower than T-piece group but not significant. Among the patients successfully completing SBT (46 in T-piece group and 51 in PSV group) re-intubation was required in 15.2% cases and 17.6% cases in T-piece group and PSV group respectively. Esteban et al.[22]found re-intubation was required in 18.75% and 18.5% cases in T-piece and PSV method respectively among the patients successfully completing SBT which closely resembles the current study.

Regarding causes of re-intubation, respiratory failure was most common, responsible in 42.9% and 33.3% cases in T-piece method and PSV method respectively. Other causes for re-intubation included upper airway obstruction, excess lung secretion/inability to protect airway, decreased consciousness level and Bronchospasm. Teixeira et al.[31] found reasons for re-intubation were respiratory failure in 34.8% cases, decreased level of consciousness in 21.8% cases, upper-airway obstruction (laryngeal oedema) in 17.4% cases, excess lung secretion/inability to protect airways in 13% cases, and bronchospasm in 13% cases. Esteban et al.[22]found reasons for re-intubation were respiratory failure in 81% cases and upper-airway obstruction in 19% cases. These study findings correlate with the current study.

In this study, successful extubation was in 67.2% and 72.4% in T-piece method and PSV method respectively, extubation failure occurred in 12.1% and 15.5% in T-piece method and PSV method respectively and SBT failure occurred in 20.7% and 12.1% in T-piece method and PSV method respectively. There was no significant difference between these two methods. Esteban et al.[22] found successful extubation in 63% cases in T-piece group and 70% cases in PSV group, extubation failure in 15% cases in T-piece group and 16% cases in PSV group. Here the percentage of patients failing the trial was significantly higher when the T-piece was used (22 versus 14%, p= 0.03). Esteban et al.[19] found successful extubation in 71% cases in T-piece group and 62.2% cases in PSV group, extubation failure in 22.6% cases in T-piece group and 18.9% cases in PSV group in patients who were difficult to wean from mechanical ventilator which showed no statistical significant difference. Here SBT failure was much higher in PSV group(10.8%) than T-piece group(3.2%). Brochard et al.[20] found weaning failure (SBT failure+ extubation failure) was significantly lower in PSV group(23%) than T-piece group(43%). Successful extubation was in 77% cases in PSV group and 57% cases in T-piece group. Matic et al.[32] showed SBT failure was higher in T-piece group (27%) than PSV group(20%).Teixeira et al.[31]found successful extubation in 85% cases in T-piece group and 83% cases in PSV group , extubation failure in 15% cases in T-piece group and 17% cases in PSV group. All of these studies closely resemble this current study.

Limitations of the study:

The study population was selected from one selected hospital in Dhaka city, so the results of the study may not reflect the exact picture of the

country. Another limitation was its observational design. The present study was conducted at a short period of time. Small sample size was also a limitation of the present study. The lack of follow-up of patients after 48 hours of extubation is another limitation.

Conclusion & recommendations

Pressure Support Ventilation method of Spontaneous Breathing Trial is as effective as T-piece method for successful extubation and it should be worthy to note here that PSV method should help the physician in the rational approach of patients ready for extubation.This study recommends the use of Pressure Support Ventilation (PSV) as a method of SBT for successful extubation. Further studies can be undertaken on the PSV method of SBT regarding successful extubation from mechanical ventilation including a large number of patients, a specific group of patients, and specific diseases of patients.

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