

Effect of Unplanned Extubation on Outcome of Mechanical Ventilation

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Unplanned extubation is a major complication of translaryngeal intubation, but its impact on mortality, duration of mechanical ventilation (MV), length of intensive care unit (ICU) and hospital stay, and need for ongoing hospital care has not been adequately defined. We performed a case-control study in a tertiary-care medical ICU, comparing 75 patients with unplanned extubation and 150 controls matched for Acute Physiology and Chronic Health Evaluation II score, presence of comorbid conditions, age, indication for MV, and sex. Forty-two (56%) patients required reintubation after unplanned extubation (74% immediately, 86% within 12 h). Thirty-three (44%) unplanned extubations occurred during weaning trials, and 30% of these patients needed reintubation (failed unplanned extubation). In contrast, 76% of patients with unplanned extubation occurring during ventilatory support required reintubation. Although mortality was similar to that of controls (failed unplanned extubation 40%, versus control 31%, $p > 0.2$), patients with failed unplanned extubation had a significantly longer duration of MV (19 versus 11 d, $p < 0.01$), longer stay in the ICU (21 versus 14 d, $p < 0.05$), and longer hospital stay (30 versus 21 d, $p < 0.01$), and survivors were more likely to require chronic care (64% versus 24%, $p < 0.001$). Successfully tolerated unplanned extubation was associated with a reduction in time from beginning of weaning to extubation (0.9 versus 2.0 d, $p = 0.06$), but with no difference in overall duration of MV, mortality, discharge location, ICU, or hospital stay as compared with these measures for controls. We conclude that unplanned extubation is not associated with increased mortality when compared with that of matched controls, although it does result in prolonged MV, longer ICU and hospital stay, and increased need for chronic care. These effects are due exclusively to patients who fail to tolerate unplanned extubation. Although successfully tolerated unplanned extubation decreased the duration of weaning trials, it had no other measurable beneficial impact on outcome.

Unplanned extubation is a major complication of translaryngeal intubation, occurring in 3 to 16% of mechanically ventilated patients (1-9). Successfully managed unplanned extubation has the potential of improving outcome by shortening the duration of intubation, thereby reducing the patient's exposure to complications of MV. Conversely, failure to successfully tolerate unplanned extubation has the potential of worsening outcome by subjecting the patient to complications of premature removal of needed ventilatory support. Not surprisingly, some studies have shown higher mortality for patients with failed unplanned extubation as compared with those who successfully tolerate unplanned extubation (4, 7, 10). Only limited conclusions can be drawn from direct comparison of these two groups, because most patients failing unplanned extubation had been on full ventilatory support, whereas most who successfully tolerated it had recovered

from acute respiratory failure and had begun weaning trials (4, 8). Therefore, the unique impact of unplanned extubation on outcome is better studied by comparison with controls not experiencing unplanned extubation. The majority of previous studies, including the only published case-control analysis, suggest no increase in mortality when comparing patients with and without unplanned extubation (1, 8-10). None of these investigations has examined the impact of unplanned extubation on duration of mechanical ventilation (MV), length of intensive care unit (ICU) and hospital stay, or the need for transfer for chronic care. In addition, the particular outcomes for those patients with failed and successfully tolerated unplanned extubations have not been compared with those of matched controls. To address this problem, we conducted a case-control study in a medical ICU of a tertiary-care academic hospital.

METHODS

Over a 44-mo period, all patients mechanically ventilated for a minimum of 12 h in the medical ICU of the New England Medical Center were prospectively followed. The medical ICU is a 10-bed closed unit, staffed by board-certified pulmonary and critical care specialists, trainees in pulmonary and critical care medicine, and medical residents who provide 24-h in-unit coverage. During the study period, 682 patients were mechanically ventilated and had a translaryngeal endotracheal tube (ETT) in place. Patient-to-nursing staff ratios varied from 1:1 to 2:1. ETTs were routinely secured with both waterproof adhesive tape and cloth tape. Physical restraints and intravenous sedation were used liberally in patients with agitation. An algorithmic sedation protocol was not used during the study period.

Unplanned extubation was defined as deliberate removal of an ETT by a patient or accidental removal of an ETT during nursing care or transport. Unplanned extubations were subdivided into failure and success groups based on whether or not reintubation was required within 72 h of extubation. For patients with multiple episodes of unplanned extubation, classification was based on the first episode. For each unplanned extubation, two controls were matched in blinded fashion from the remaining mechanically ventilated patients who did not experience unplanned extubation. Controls were matched for five variables in the following order: Acute Physiology and Chronic Health Evaluation (APACHE) II score ± 3 points, presence of one or more comorbid conditions, age ± 5 yr, indication for MV and sex. APACHE II scores were determined during the first 6 h of MV. Comorbid conditions consisted of active malignancy (untreated or currently undergoing treatment), cirrhosis, human immunodeficiency virus (HIV) infection, or organ transplantation. Indications for MV were characterized as respiratory (e.g., exacerbation of chronic obstructive pulmonary disease, pneumonia, acute respiratory distress syndrome), cardiac (e.g., acute myocardial infarction, acute congestive heart failure), other (e.g., acute neurologic syndrome, gastrointestinal bleeding, drug overdose, sepsis) or some combination of these. The presence of acute hepatic failure (bilirubin ≥ 5 mg/dl and INR ≥ 1.5) and acute renal failure (requiring dialysis, excluding chronic dialysis patients) at onset of MV was recorded. It was noted whether or not weaning trials had been initiated at the time of unplanned extubation. If weaning trials had not yet begun, patients were considered to be on full ventilatory support.

Although a strict protocol was not used, patients in the study were subjected to the usual medical ICU weaning approach. This was accomplished by a reduction in the intermittent mandatory ventilation (IMV) rate and/or pressure support ventilation (PSV) level (for patients ventilated with IMV plus PSV), or a reduction in the level of

(Received in original form August 18, 1999 and in revised form November 11, 1999)

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Am J Respir Crit Care Med Vol 161, pp 1912-1916, 2000
Internet address: www.atsjournals.org

PSV alone (for patients on PSV). Planned extubation occurred only if the patient tolerated at least 0.5 to 2 h of minimal ventilatory support (spontaneous breathing trial) defined as PSV \leq 10 cm H₂O, and IMV rate of 0, and a positive end-expiratory pressure level \leq 5 cm H₂O, and passed the weaning trial by satisfying the following criteria: Sa_O₂ \geq 90% or Pa_O₂ \geq 60 mm Hg on a fraction of inspired oxygen (Fi_O₂) \leq 0.40 to 0.50; need for infrequent suctioning of airway secretions; alert mental status; presence of cough and adequate airway protective mechanisms; stable hemodynamic profile; stable cardiac rhythm; increase in Pa_CO₂ $<$ 10 mm Hg; and decrease in pH $<$ 0.10. In general, isolated criteria such as tachypnea, tachycardia, diaphoresis, agitation, or anxiety were considered inadequate for deeming the patient a weaning failure. Criteria for considering reintubation included an increase in Pa_CO₂ $>$ 10 mm Hg and decrease in pH $>$ 0.10; Pa_O₂ $<$ 60 mm Hg or Sa_O₂ $<$ 90% on Fi_O₂ $>$ 0.50 to 1.0; increased signs of respiratory work (tachypnea, use of accessory respiratory muscles, thoracoabdominal paradox); or inability to protect the airway because of upper airway obstruction or excess pulmonary secretions.

All patients were followed to hospital discharge. Discharge to chronic care was said to occur when the patient was transferred to a rehabilitation unit, long-term acute care unit, or skilled nursing facility.

Statistics

Defined outcomes included duration of MV, duration of ICU and hospital stay, hospital mortality, discharge site for survivors (e.g., home or chronic care unit), and need for tracheostomy. Initially, patients with unplanned extubations were compared with controls. Subsequently, comparisons were made both between patients with unplanned extubation failure and success and of each of these groups with its respective control group. Continuous variables were compared through Student's *t* test. Dichotomous variables were compared through the chi square method with a two-tailed Fisher's exact test. All statistics were calculated with statistical software (SPSS version 6.1; SPSS Inc., Chicago, IL).

RESULTS

Unplanned extubations occurred in 75 patients (67% of them men), representing 11% of all mechanically ventilated medical ICU patients, for a total of 88 events. Therefore, when all mechanically ventilated patients are considered, there were 1.6 unplanned extubations per 100 d of intubation. Sixty-four patients (85%) had one, nine patients (12%) had two, and two patients (3%) had three unplanned extubations. All patients with unplanned extubations had been orally intubated. Seventy-one patients had deliberate and four patients had accidental unplanned extubations. Table 1 shows that the groups

were well matched for age, APACHE II score, presence of comorbid conditions, cause for acute respiratory failure, and presence of acute renal or hepatic failure. There was a trend toward a higher incidence of patients with HIV infection in the unplanned extubation group, but the absolute number of patients with this condition was small. Sixty-one patients (81%) with unplanned extubation and 115 (77%) controls received intravenous sedation in the form of benzodiazepines, narcotics, or phenothiazines ($p > 0.2$).

Forty-two (56%) patients required reintubation after an unplanned extubation. Thirty-one (74%) of these patients required reintubation immediately (within 1 h) and 36 (86%) required reintubation within 12 h. Thirty-three (44%) unplanned extubations occurred during weaning trials, and 30% of the patients needed reintubation. In contrast, 76% of patients with unplanned extubations during full ventilatory support required reintubation ($p < 0.001$).

Table 2 shows the outcomes for all patients with unplanned extubations as compared with all controls. There was no difference between the groups in mortality or the likelihood of needing a tracheostomy. In contrast, patients with unplanned extubation spent a longer time on MV and experienced a longer duration of stay in the ICU and in the hospital. Among survivors, patients with unplanned extubation were more likely to need transfer to chronic care.

Figures 1 and 2 show mortality, discharge site, duration of MV, and duration of ICU and hospital stay for patients with unplanned extubation failure and successes, and their respective controls. Although there was a trend toward a higher mortality for patients with unplanned extubation failure as compared with success ($p = 0.08$), neither of these groups showed any difference from their respective controls. Mortality was 40% among patients with unplanned extubation failure and 31% among their controls ($p > 0.2$). Mortality was 21% among patients with successfully managed unplanned extubation, as compared with 28% for their controls ($p > 0.2$).

Unplanned extubation occurred from 4.7 ± 6.0 d after intubation among patients who failed to tolerate this event. After reintubation, these patients required an additional 14.3 ± 15.2 d of MV. Patients with unplanned extubation failure had a significantly longer duration of MV and stay in the ICU and hospital than did their controls or patients who successfully tolerated unplanned extubation (Figure 2). Patients with failed unplanned extubation were also more likely to require chronic care and less likely to be discharged directly to their homes.

In contrast, patients with unplanned extubation who did not require reintubation had a similar mortality, duration of MV, discharge location, and ICU and hospital stay to those of their controls. Among patients undergoing weaning trials,

TABLE 1

COMPARISON OF UNPLANNED EXTUBATIONS TO CONTROLS

| | Unplanned Extubation (n = 75) | Control (n = 150) | p Value |
|-----------------------------|----------------------------------|----------------------|---------|
| Age, yr | 59 \pm 17 | 57 \pm 16 | > 0.2 |
| APACHE II score | 15 \pm 5 | 15 \pm 5 | > 0.2 |
| Comorbid conditions | 34 (45%) | 68 (45%) | > 0.2 |
| Cirrhosis | 4 (5%) | 13 (9%) | > 0.2 |
| HIV infection | 4 (5%) | 2 (1%) | 0.10 |
| Organ transplant | 3 (4%) | 7 (5%) | > 0.2 |
| Malignancy | 19 (25%) | 28 (19%) | > 0.2 |
| Sepsis | 9 (12%) | 18 (12%) | > 0.2 |
| Acute lung injury | 11 (15%) | 27 (18%) | > 0.2 |
| COPD exacerbation | 17 (23%) | 30 (20%) | > 0.2 |
| Pneumonia | 25 (33%) | 61 (41%) | > 0.2 |
| Acute myocardial infarction | 11 (15%) | 16 (11%) | > 0.2 |
| Acute CHF | 17 (23%) | 25 (17%) | 0.18 |
| Acute hepatic failure | 0 (0%) | 3 (2%) | > 0.2 |
| Acute renal failure | 7 (9%) | 15 (10%) | > 0.2 |

Definition of abbreviations: APACHE = Acute Physiology and Chronic Health Evaluation; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; HIV = human immunodeficiency virus.

TABLE 2
OUTCOMES

| | Unplanned Extubation (n = 75) | Controls (n = 150) | p Value |
|-----------------------------|----------------------------------|-----------------------|---------|
| Mortality | 24 (32%) | 45 (30%) | > 0.2 |
| Chronic care* | 26 (51%) [†] | 32 (30%) [†] | < 0.05 |
| Home | 25 (49%) [†] | 73 (70%) [†] | < 0.05 |
| Mechanical ventilation days | 13 \pm 15 | 9 \pm 12 | < 0.05 |
| ICU days | 17 \pm 16 | 12 \pm 13 | < 0.05 |
| Hospital days | 25 \pm 22 | 19 \pm 18 | < 0.05 |
| Tracheostomy | 9 (12%) | 12 (8%) | > 0.2 |

Definition of abbreviation: ICU = intensive care unit.

* Rehabilitation unit, long-term acute care unit, skilled nursing facility.

[†] Percentages are for hospital survivors.

those who successfully tolerated unplanned extubation (n = 23) had a shorter time between beginning of weaning and extubation than did controls (n = 54) (0.9 ± 1.0 d versus 2.0 ± 3.9 d, $p = 0.06$). This reduction in weaning time did not significantly reduce the overall duration of MV for these patients (5.4 ± 5.8 d, versus 6.5 ± 7.9 d for controls, $p > 0.2$).

As compared with controls, patients failing unplanned extubation tended to be more likely to also require reintubation after planned extubation (12 of 42 patients (29%) with failed unplanned extubation versus, 13 of 84 (15%) controls, $p = 0.08$). Eight patients failing to tolerate planned extubation (four in each group) died. The majority of failed planned extubations occurred after the episode of failed unplanned extubation (seven of 12, or 58%). *Post hoc* analysis restricted to patients without failed planned extubation did not change the outcomes analysis.

DISCUSSION

Our case-control study of unplanned extubation in medical ICU patients made several unique findings. First, unplanned extubation was associated with a prolonged duration of MV, ICU stay, and hospital stay. Second, although mortality was similar, hospital survivors who had had unplanned extubations were more likely to require continued care than to be well enough to go directly home. These effects were due exclusively to the outcome for patients who failed to tolerate unplanned extubation. Third, successfully tolerated unplanned extubation reduced the duration of weaning, but had no other mea-

surable beneficial impact on outcome. The prevalence of unplanned extubation in our study cohort was well within the range reported by other investigators. We also confirmed the findings of others that unplanned extubation during weaning trials is usually successfully tolerated, whereas it typically fails when the patient is on full ventilatory support. In agreement with previous findings, the overwhelming majority of reintubations for failed unplanned extubation in our study occurred in the first hour after the event.

Recent studies show higher ICU and hospital mortality for patients who fail to tolerate planned extubation than for those successfully extubated (11-13). Those with failed planned extubation also experience a substantially longer duration of MV, ICU stay, and hospital stay, and are more likely to require some form of chronic care (11). With regard to patients with unplanned extubation, the results of our study are in agreement with those of previous studies indicating a higher mortality for patients who fail to tolerate unplanned extubation (range: 28 to 51%) than for those who succeed (range: 0 to 12%) (4, 7, 10, 14). It must be emphasized that in contrast to planned extubation, unplanned extubation can occur independently of whether or not the process that led to MV has improved.

To define any excess mortality attributable to unplanned extubation, comparison with mechanically ventilated controls not experiencing unplanned extubation is necessary. Betbese and colleagues and Boulain and coworkers found no difference in mortality when they compared patients with unplanned extubation with unmatched mechanically ventilated patients without unplanned extubation (8, 9). Atkins and colleagues conducted a retrospective case-control study (matching for age, sex, primary discharge diagnosis, and time hospi-

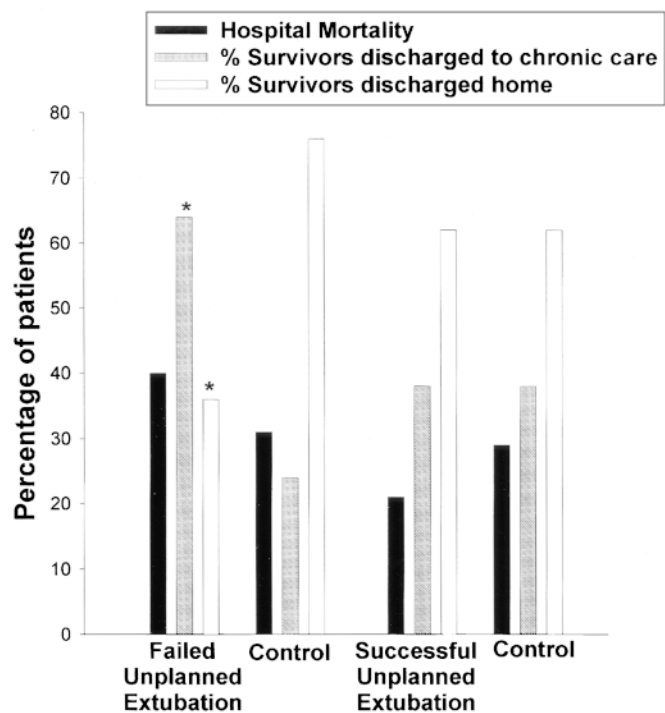


Figure 1. Comparison of hospital mortality, discharge to chronic care unit (rehabilitation unit, long-term acute care unit, or skilled nursing facility), or discharge to home for patients with failed unplanned extubations, those with successful unplanned extubations, and their respective matched controls. When compared with patients with successful unplanned extubations, patients with failed unplanned extubations tended to have higher mortality, greater need for a chronic care unit, and a lower likelihood of discharge to home ($p < 0.10$). * $p < 0.05$, failed unplanned extubation versus control.

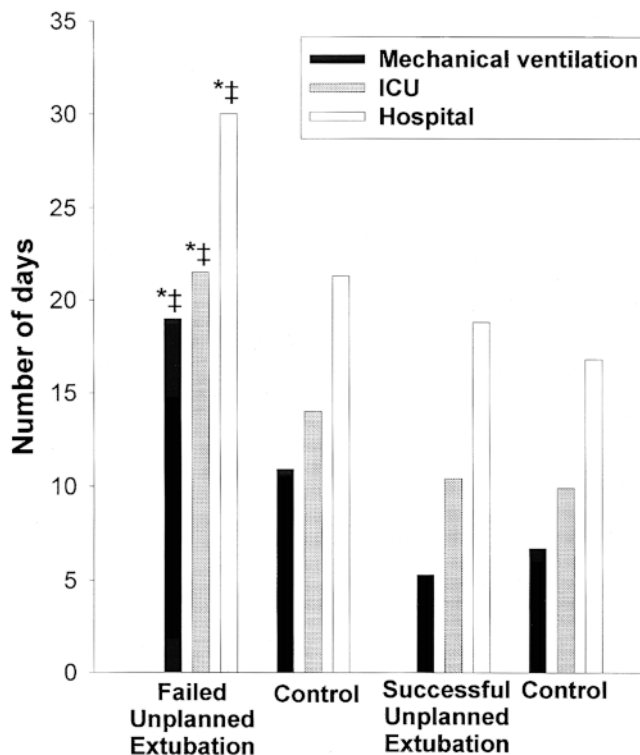


Figure 2. Comparison of duration of MV, ICU stay, and hospital length of stay for failed unplanned extubations, successful unplanned extubations, and their respective matched controls. * $p < 0.05$, failed unplanned extubation versus control; † $p < 0.05$, failed unplanned extubation versus successful unplanned extubation.

talized) in the ICUs of a tertiary-care referral center, and found similar mortality for all patients with unplanned extubations as compared with controls (38% versus 25%, $p > 0.05$) (10). Their study did not control for severity of illness or presence of important comorbid conditions, and did not stratify on the basis of success or failure to tolerate unplanned extubation. After controlling for these important factors, we found no increase in mortality for patients with unplanned extubation. In addition, we found that mortality was not significantly increased for patients who failed to tolerate unplanned extubation as compared with controls. Most patients who fail to tolerate unplanned extubation had been receiving full ventilatory support, having not yet sufficiently recovered from their acute illness to begin weaning trials (4, 8). Their outcome may be overwhelmingly governed by underlying severity of illness, the cause for acute respiratory failure, and the presence of comorbid factors. Any incremental mortality resulting from failed unplanned extubation may be relatively small and difficult to detect. Two recent studies found that patients reintubated within 12 h of planned extubation had a lower mortality than those reintubated later than this (15, 16). As noted by others, we found that nearly 90% of patients who failed to tolerate unplanned extubation were reintubated within 12 h (most within 1 h) (4, 9, 10, 14, 17, 18). Rapid reinstatement of ventilatory support and control of the airway of patients who fail to tolerate unplanned extubation may prevent the development or reduce the severity of pneumonia or new organ failure; both of which could contribute to increased mortality (19).

Despite the lack of its association with increased mortality, we found that failed unplanned extubation increased the duration of MV, ICU stay, hospital stay, and need for chronic care. This may be related to the frequent development of complications related to reintubation for failed unplanned extubation (4, 10, 17). Although immediate death from these complications has been infrequently reported, they may lead to a longer period of necessary mechanical ventilation (7, 9, 17, 18, 20). Similarly, although rapid reestablishment of ventilatory support may reduce the risk of death, significant organ failure may still occur, ultimately leading to a delay in recovery. Moreover, increased amounts of sedative medications may be used after reintubation, to prevent a recurrence of unplanned extubation. Kollef and associates have recently shown that increased use of continuous intravenous sedation results in a longer duration of MV (21).

Approximately 30 to 70% of unplanned extubations do not result in reintubation (1, 3–10, 14, 17, 20). Similarly, we found that 44% of unplanned extubations were successfully tolerated, and that one third of these occurred while patients were still receiving full ventilatory support (e.g., had not yet started spontaneous breathing trials). These observations are consistent with the hypothesis that physicians have difficulty judging when patients can be liberated from MV. Because MV is associated with numerous complications, some of which increase with longer duration of MV, it is argued that patients must be liberated from the ventilator as soon as possible. We found that successful unplanned extubation resulted in a $> 50\%$ reduction in the duration of weaning trials as compared with those of controls, but this did not significantly reduce the overall duration of MV, length of ICU or hospital stay, mortality, or need for chronic care. This may reflect the fact that in this cohort, weaning constituted less than one third of total ventilator time. Although the complications associated with intubation increase with duration of ventilation, the incremental risk of one additional day of MV, especially once weaning trials have commenced, may be trivial. Similarly, two studies of protocol-directed weaning did not demonstrate reductions in mortality or length of ICU or

hospital stay, despite finding statistically significant (but small) reductions in the duration of MV (22, 23).

Our study had several limitations. First, we studied only medical ICU patients, and our findings may therefore not pertain to patients experiencing unplanned extubation after surgery. Second, we did not record severity of illness or the presence of acute organ failure at the time of unplanned extubation. Third, we did not examine the etiology of failure of unplanned extubation. Etiology of planned extubation failure has been shown to be an important determinant of outcome, with mortality highest for respiratory failure and congestive heart failure. Extubation failure resulting from either upper airway obstruction or an inability to protect the airway has little impact on outcome (12, 13, 15). Studies by other investigators indicate that 79 to 91% of unplanned extubation failures result from respiratory distress or ventilatory failure (hypoxemia, hypercapnia, tachypnea, or signs of increased work of breathing) (4, 12–15, 17). Problems with airway protection or abnormal mental status account for only 8 to 19% of failures of unplanned extubation. Fourth, because three quarters of the patients who failed to tolerate unplanned extubation in our study were reintubated immediately, the effect of time to reintubation could not be adequately examined. We did note that three of six (50%) patients who were reintubated 12 or more hours after unplanned extubation died, as compared with 38% (14/36) who were reintubated within 12 h ($p = \text{NS}$). Additionally, the mortality among patients with successful unplanned extubation in our study was somewhat higher than previously reported. Explanations for this include the very high prevalence of comorbid conditions in our cohort, and the late reintubation (more than 7 d after unplanned extubation) fact of five patients, of whom three died.

In conclusion, failed unplanned extubation is associated with an increased duration of MV, length of ICU and hospital stay, and need for chronic care. Failed unplanned extubation does not increase mortality, perhaps because of the minimal delay in reestablishing ventilatory support in the vast majority of patients. In our study, successfully tolerated unplanned extubation reduced the duration of weaning trials, but had no other measurable beneficial effect on outcome.

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