An Evaluation of Ventilator Reliability: A Multivariate, Failure Time Analysis of 5 Common Ventilator Brands

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INTRODUCTION: Mechanical ventilator failures expose patients to unacceptable risks and are expensive. By identifying factors that correlate with the amount of time between consecutive ventilator failures, we might reduce patient risk, save money, and shed light on a number of important questions concerning whether reliability changes as a function of time. OBJECTIVE: Investigate the correlation between several explanatory variables and the time between consecutive ventilator failures and address the following questions: (1) Are ventilators as safe and reliable following repairs as they were before failing? (2) Does reliability change significantly as a ventilator is used or ages? (3) Does a hospital's particular operating environment play a role in ventilator reliability? (4) Are ventilator service contracts worth the money? METHODS: A retrospective review was conducted using repair and maintenance records from 2 hospitals: a 570-bed teaching hospital and a 410-bed local community hospital. Records were examined from a total of 66 individual ventilators, of 5 different brands, used between July 1, 1991, and January 3, 2001. The ventilators included 13 Tyco-Mallinckrodt Infant Star, 10 Bird VIP, 11 Bird 6400ST, 16 Bird 8400STi, and 16 Tyco-Mallinckrodt 7200ae. The dependent variable was the operating time between or before unexpected mechanical failures; this was determined by the difference between hours logged on the ventilator hour meter at the time of failure and that recorded when the study began, or when the ventilator was new. Thereafter (when applicable), the time before failure was the difference in hours at consecutive failures. Seven independent explanatory covariates were selected and analyzed as potential correlates with time between failures. Another independent variable, the site of ventilator use (community or teaching hospital), was also tested for significance. Data were analyzed using the Cox proportional hazard model, the multiple-groups survival statistic, and the Cox-Mantel test. RESULTS: In 2,567,365 hours of ventilator operation, 290 observations were recorded (226 failures and 64 censored observations). Two of the 7 covariates were judged time-dependent, excluded from the Cox model, and evaluated using other techniques. Of the 5 remaining covariates, 2 were significantly related to reliability, both indirectly. There was no difference in reliability, regardless of how many times a ventilator had been previously repaired, but hospital environment did significantly affect reliability. CONCLUSIONS: Ventilator reliability depends on a number of factors. This study indicates that, on average, ventilator reliability improves the more a ventilator is used and the longer the brand has been commercially available. The number of previous ventilator repairs did not affect reliability, but the hospital environment did. These data, if validated, should help to enhance our understanding of ventilator reliability and could eventually have profound economic and safety implications as well. *Key words: ventilator reliability, ventilator failure, ventilator maintenance, mechanical failure.* [Respir Care 2001;46(8):789–797]

Introduction

A reasonable estimate suggests that today, one third to one half of all intensive care unit patients receive ventilatory support during their hospital stays.[1] In the United States alone, 50,000 mechanical ventilators are currently in use (100,000 or more worldwide).[2] Further estimates suggest that in the United States as many as 1.5 million patients receive some form of ventilatory support outside of operating and recovery rooms each year.[2,3] With so many ventilators in use, a large number of mechanical failures seems inevitable.

Modern mechanical ventilators represent a large capital expense for most hospitals (at $10,000–30,000 each, or more),[2] are costly to repair ($1,000 or more per repair),[4] and their maintenance often requires a considerable invest-

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ment of time and money. More importantly, unexpected ventilator failures expose the patient to potential harm; the risks can be considerable.[5,6] While there are now some data quantifying the *average* reliability of several common ventilators,[7] there are no data identifying which factors, if any, are correlated with ventilator reliability or what happens to reliability as a ventilator ages or is used extensively. Unbiased information of this type is important for a number of reasons. First, individual ventilators or ventilator brands prone to failure represent poor investments, particularly over time. Moreover, if ventilator reliability changes as ventilators age, an initially reliable brand may become less reliable as it ages, or vice-versa. Some hospitals attempt to avoid unexpected repair costs as ventilators age by purchasing a service contract for each ventilator, yet there are no compelling data to suggest whether such contracts actually save money. Another important issue involves determining how long, on average, ventilators can be used safely before they require replacement. In addition, ventilator manufacturers often suggest that the environment in which a ventilator is operated—factors such as a hospital's compressed air quality or the severity and frequency of electrical power disruptions—can strongly influence a ventilator's reliability, but is this accurate? Finally, there remains another, unproven premise involving mechanical ventilators,[7] which is that administrators, clinicians, and risk managers all tacitly assume that, following each repair, a mechanical ventilator is as safe and reliable as it was when new. Is this a reasonable and valid assumption? Or does the risk of unexpected ventilator failure increase following one, two, or multiple failures?

The present study was designed to analyze the relationship between ventilator reliability, as measured by the time before failure, and a number of independent variables—factors potentially related to reliability, such as chronological age and the number of previous failures. The main objective is to shed light on or answer directly some of the unanswered questions involving the reliability of the current generation of mechanical ventilators.

Methods

The study consisted of a retrospective review and analysis of repair and maintenance records for 5 brands of mechanical ventilators maintained and used at 2 hospitals: a 570-bed, university-affiliated hospital with physician, nursing, pharmacy, and respiratory therapy training programs, and a 410-bed community hospital. A total of 66 ventilators were studied: 13 Tyco-Mallinckrodt Infant Star (STAR), 10 Bird VIP (VIP), 11 Bird 6400ST (6400ST), 16 Bird 8400STi (8400STi) (all Bird ventilators made by Thermorespiratory Group, Palm Springs, California), and 16 Tyco-Mallinckrodt 7200ae (7200ae) (Tyco-Mallinckrodt, Carlsbad, California). Each ventilator was used for some portion of or throughout the period beginning July 1, 1991, and ending January 3, 2001. Ventilators of the studied brands purchased during the course of the study were added into the study on the date they were placed into use. Once in the study, each ventilator was either ready for use or in use throughout the remainder of the study (except for time out for troubleshooting, repairs, or calibration). The chronological age of each ventilator (in years) was determined by using the month and year the ventilator was first available for use in the hospital as day 1. Institutional repair and maintenance records were obtained for each of the studied ventilators and used to determine the date each ventilator was first placed into service, the date each reported failure was noted, the total operating hours logged on the hour meter at the start of the study or when placed into use, and the hours logged the day each failure was reported. For the purpose of the study, a failure was defined as any unexpected problem that rendered a ventilator inoperable or unsafe to use until it was either repaired or recalibrated by a biomedical engineer or factory-certified technician. Documented minor repairs, often performed by bedside clinicians, were excluded. Using this information, the dependent variable (the time before failure, or the number of hours each ventilator operated before experiencing a failure) was determined. Because most ventilators experienced several failures during the course of the study, the dependent variable, also included observations recorded as the number of hours a ventilator operated without incident between consecutive failures. For this study the data were right-censored. That is, at the conclusion of the study it was not known how long each ventilator would continue to operate before failing (again, in most cases). For that reason, the time between the last documented failure and the conclusion of the study was considered a censored event, except for those ventilators awaiting repairs when the study ended.

There are a number of independent variables or covariates that potentially correlate with the dependent variable; a practical list, which is neither complete nor exhaustive, was formulated (Table 1). Each of these variables was evaluated separately for each observed failure and then analyzed as a prognostic covariate.

Manufacturers provided (1) the month and year each studied brand of ventilator was first commercially available, (2) the suggested retail price of a fully equipped version of each studied brand of ventilator (including a graphics monitor if applicable), and (3) the recommended preventive maintenance retail costs (all in 2001 dollars).

Statistical Analysis

To determine frequency distribution best describing the study data, the data were compared against the 4 common, nonlinear, distribution models generally associated with

Table 1. Definition of Prognostic Variables

1. Age	Ventilator chronological age, measured in years of use
2. Brand	Ventilator brand (eg, VIP or STAR)
3. Purchase price	Suggested retail cost (2001 dollars) for a fully-equipped version of a ventilator brand, including a graphic monitor if applicable
4. Failures	Number of previous failures/repairs
5. Maintenance cost	Suggested retail cost (2001 dollars) for preventive maintenance of a ventilator brand each 10,000 hours of usage
6. Product age	Number of years since a specific ventilator brand was first released for sale
7. Site	Site of ventilator use—community or teaching hospital
8. Use	Ventilator use, measured in hours of operation

survival or time before failure data. Because time before failure data sets generally assume a nonlinear frequency distribution and contain censored observations, correlations were tested for using the standard Cox proportional hazard multiple regression model.[8,9] This particular approach is exceptionally practical for such data sets because it makes no assumptions concerning the underlying frequency distribution of the data. The standard Cox model, however, assumes that each prognostic covariate incorporated into the model satisfies the so-called proportional hazard assumption.[8] The validity of that assumption was tested individually for each studied covariate, using the log-log Kaplan-Meier graphical approach.[8] Covariates judged as time-dependent (not satisfying the proportional hazard assumption) were noted, omitted from the multiple regression model, and analyzed separately.

The dichotomous covariate, site (see Table 1), was also omitted from the multiple regression model because under normal circumstances it does not represent a variable. Although the location of use *was* a variable in this particular study, as a general rule ventilators are used only at the facility (eg, hospital or medical center) owning them. Significance for this covariate was tested for by separating the time before failure data into 2 groups, based on the location of use (teaching or community hospital). A second test for significance was made by removing any ventilator brands, from either group, not in use at both facilities. The hypothesis that the time before failure was not different at the 2 study locations was tested using the Cox-Mantel test.

Based on strong evidence of nonparallelism seen on the relevant Kaplan-Meier plots, both the brand and use variables were determined to be time-dependent. To investigate this situation, data for each of the 5 brands of ventilator were divided into 3 groups, based on use:

1. Failures that occurred in the first 15,000 hours of ventilator operation (use).
2. Failures that occurred in the time period from 15,001 to 30,000 hours of ventilator operation.
3. Failures that occurred after 30,001 hours of ventilator operation.

For each of the 5 ventilator brands, the time before failure in each of these 3 groups was compared against each other group, using the survival statistic for multiple groups. When differences were noted, multiple comparisons were performed using the Cox-Mantel test.

Throughout the statistical analysis, α was set at 0.05 for statistical significance. All descriptive statistics, hypothesis testing, and graphical analysis were performed with commercially-available software (STATISTICA for Windows, version 5.5A, StatSoft, Tulsa, Oklahoma).

Results

During the 9.5-year study, the 66 study ventilators operated for a combined total of 2,567,365 hours. During that period, 290 observations were recorded (Table 2). The average ventilator survived 8,857 hours of use before experiencing an unexpected mechanical failure. Table 3 shows statistical data for the 7 continuous study variables. The study data differed significantly from all of the common failure time distribution models (exponential, linear hazard, and Gompertz),[8] except 2 weighted versions of the decreasing Weibull distribution model (Fig. 1).

Based on the Cox proportional hazard model, there was no significant relationship between the covariates failures, purchase price, maintenance cost, and the dependent variable, time before failure. However, both of the variables—chronological age ($p < 0.0001$) and product age ($p < 0.0001$)—were strongly but inversely related to the time before failure. That is, as the magnitude of either of those variables increased, the cumulative frequency of unexpected failure decreased.

Ventilators used at the community hospital were significantly more reliable than those used at the teaching hospital ($p = 0.0004$) when all brands were compared, and also significantly more reliable ($p = 0.0003$) when only those brands used at both hospitals were compared.

There were also many significant differences noted when the relationship between the 2 time-dependent covariates, ventilator brands and use, were analyzed (Fig. 2). For several ventilators (STAR, VIP, and 6400ST), the time before failure was significantly improved at each of 3 increasing levels of use tested. The 8400STi improved dramatically from the first level to the second, but showed no difference thereafter. Only the 7200ae showed no difference in the time before failure between any of the use levels tested.

Table 2. Ventilator Data

Brand*	STAR	VIP	6400 ST	7200ae	8400STi	Results
Number of ventilators	13	10	11	16	16	66 (Total)
Failures (*n*) (censored observations)	46 (13)	22 (10)	56 (11)	74 (14)	30 (16)	226 (64) (Totals)
Time before failure: total (h)	8,303 ± 8,990	7,595 ± 7,266	5,879 ± 6,191	10,071 ± 9,784	12,513 ± 10,477	8,857 ± 8,986 (Mean ± SD)
Use during study: average (h)	498,810	243,099	393,881	857,090	574,485	2,567,365 (Total)
Use/ventilator/year† (h)	5,119	4,021	3,632	6,522	5,038	5,098 (Mean)

*Ventilator brands and manufacturers are described in the text.
†Because all ventilators did not participate for the entire study, averages were obtained by averaging the hours of use divided by the years of participation for each ventilator.

Table 3. Continuous Study Variables

Variable	Variable Type	Mean	Standard Deviation	Minimum	Maximum	Time-Dependent
Age (y)	Independent	6.69	3.97	0.08	17.8	No
Failures (*n*)	Independent	2.52	2.56	0	14	No
Maintenance cost ($)	Independent	2,778.7	237.96	2,430	3,220	No
Product age (y)	Independent	11.13	3.93	1.0	18.1	No
Purchase price ($)	Independent	18,650.6	4,911.5	10,500	23,675	No
Use (h)	Independent	33,098	23,060	44	103,908	Yes
Time before failure (h)	Dependent	8,856.9	8,985.9	19	46,585	NA

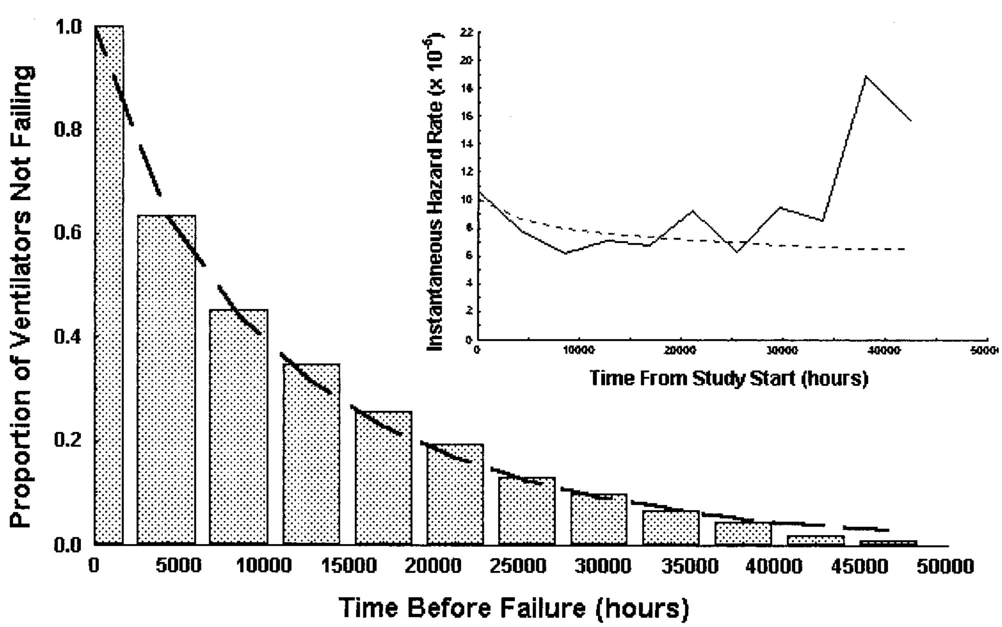

Fig. 1. Cumulative frequency distribution histogram plotting a series of 12 equal intervals of time before failure against the proportion of ventilators not having yet experienced a mechanical failure (or still surviving) within each time interval during the study. The appropriate frequency distribution model for the data is determined by the best-fit hazard function (insert). The actual hazard function plot (solid line) is not statistically different (p = 0.117) from a weighted, decreasing Weibull function (dotted line). A representative decreasing Weibull survival curve of the form

$$S(t) = ae^{-at^b} bt^{(b-1)}$$

(wherein S(t) is survival time, a and b are parameters of the distribution, t = time, and e = 2.718) is shown superimposed on the actual hazard function.

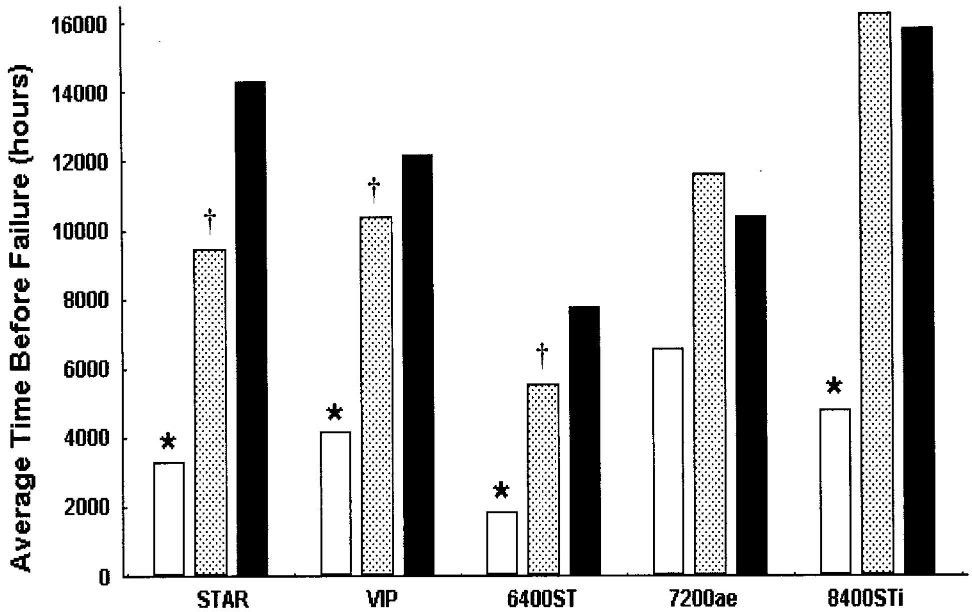

Fig. 2. Average time before ventilator failure for each of the 5 ventilator brands studied. Failure data for each ventilator brand was subdivided into 3 groups: (1) failures occurring in the first 15,000 hours of use (white columns), (2) failures occurring between 15,001 and 30,000 hours of use (stippled columns), and (3) failures occurring after 30,000 hours of use (black columns). STAR = Tyco-Mallinckrodt Infant Star ventilator. VIP = Bird VIP ventilator. 6400ST = Bird 6400ST ventilator. 7200ae = Tyco-Mallinckrodt 7200ae ventilator. 8400STi = Bird 8400STi ventilator. * $p < 0.05$ compared to failures in groups 2 and 3. † $p < 0.05$ compared to group 3.

Discussion

The primary findings of this study are:

1. For the 5 studied brands there was no relationship between ventilator reliability and purchase price or maintenance costs.

2. There is a strong but inverse relationship between reliability and a studied ventilator's age and product age; that is, on average, the older a ventilator is and the longer it has been commercially available, the greater its time before failure.

3. In this study, the site of use (the environment in which the ventilator was operated) played an important role in determining the time before failure.

4. These particular ventilators were just as safe and reliable, regardless of how many times they had previously failed.

Some of the findings in this study were unexpected and contrary to conventional thinking. For instance, while many of us are enticed by items "on sale," collectively, most of us still tend to believe that, as a rule, quality and reliability are a direct function of the purchase price. Clearly, the ventilators in this study did not adhere to that axiom. It is also interesting to note that the prices paid for long-term, preventive maintenance did not influence reliability. Thus, if these ventilators are representative, buying the most expensive ventilators or paying more for preventive maintenance does not confer any quantifiable advantage in terms of safety and reliability.

Another common tenet often applied to ventilators is the belief that most mechanical devices experience failures on an ever-increasing basis as they are used and age.[4] For example, most of us believe that, compared to a new car, one with 100,000 miles on the odometer will have more frequent breakdowns. Figure 3 illustrates the failure rate of the studied ventilators as they were used and aged, depicting the average time before failure versus total hours of ventilator use. When this graph is compared to the concept of an increasing failure rate with age and use, these data present a very different picture. Clearly, for the first 40,000 hours of use or 8 years of use (average use/ventilator/year was approximately 5,000 h; see Table 2), these ventilators became *increasingly* reliable. However, as the superimposed, best-fit polynomial model shows (see Fig. 3), after accumulating over 40,000 hours of use (8 yr), average ventilator reliability seems to have reached a peak. Nevertheless, although reliability deteriorates somewhat beyond 40,000 hours of use, it is still vastly superior to that of a "new" ventilator; this statement is underscored by simply comparing the average reliability of the ventilators with more than 70,000 hours of use to that of relatively new ones (with less than 10,000 hours of operation). Unfortunately, while this information affords us an understanding of how ventilator reliability may change over

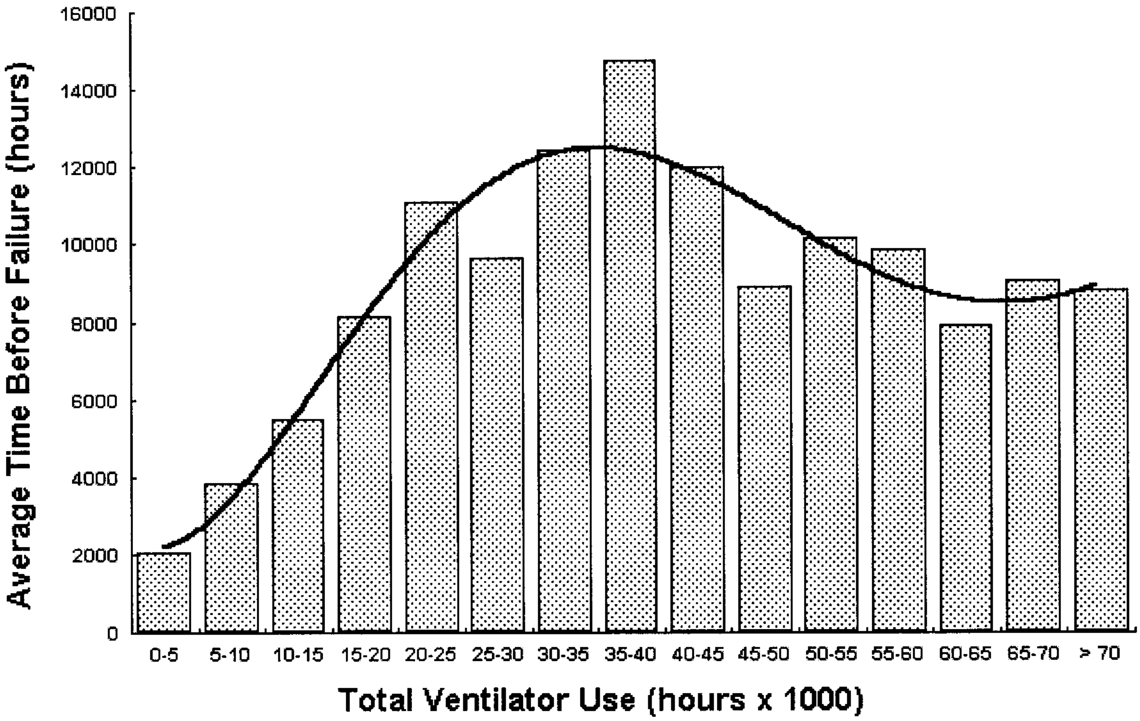

Fig. 3. Average time before failure for 66 mechanical ventilators plotted against total ventilator use. Failure data were subdivided into 15 increments, starting with the failures occurring between 0 and 5,000 hours of use; each successive increment represents the failures that occurred during the next 5,000 hours of ventilator use, except for the final increment, which represents all failures occurring after 70,000 hours of ventilator use. Use for this group of ventilators averaged approximately 5,000 hours/ventilator/year. Superimposed is the best-fit polynomial equation, fitted using the least squares technique.

time, it does not answer the question of how long ventilators can be used safely. However, the information does represent good news for cost-conscious hospital administrators, specifically those hoping to limit capital expenditures by not purchasing new ventilators every 10 years. In fact, in today's cost-conscious health care environment, the common practice of periodically "trading in" ventilators simply because they are "old" might constitute a form of fiscal irresponsibility. Based on these data, it is not an unreasonable approach to continue to repair, maintain, and use mechanical ventilators until they are no longer cosmetically acceptable or until they fail to provide clinicians with the necessary alarms or modes required by the hospital's standard of respiratory care.

It is the goal of any multiple regression analysis to state whether any of the studied covariates correlate with the dependent variable; however, without a way to quantify the effect of any significant covariate(s), the knowledge is of limited practical value. The standard Cox model is particularly useful because it not only determines which covariates are significantly related to survival, but can also be used to graphically display the effect on survival produced by any conceivable level (or combination of levels) of studied covariates. A series of such graphs depicting the effects of ventilator age and product age on time before failure are now examined.

When new products are introduced, the phrase "learning curve" is often heard. The implication is that at the time new products are first released for sale, manufacturers possess very little data concerning the product's long-term reliability. As customers begin to use these products, however, they may begin to experience failures—often too soon. If any particular components appear to be failing too frequently (especially during the warranty period), ethical manufacturers make an effort to replace the faulty component (or components) with a more reliable one. Recalls in the automobile industry represent one example of this process. Product age was included in this analysis to assess whether this process plays an important role in ventilator reliability. In this regard, these data are clear that, on average, the longer a specific brand of ventilator has been on the market the more reliable it becomes (Fig. 4). A possible explanation for this finding is that manufacturers ensure that during repair or periodic overhaul, components recognized as prematurely failing are exchanged for more reliable ones. Some manufacturers freely acknowledge this process and state that their ventilators will become more reliable with age.[10] This process also helps to explain why,

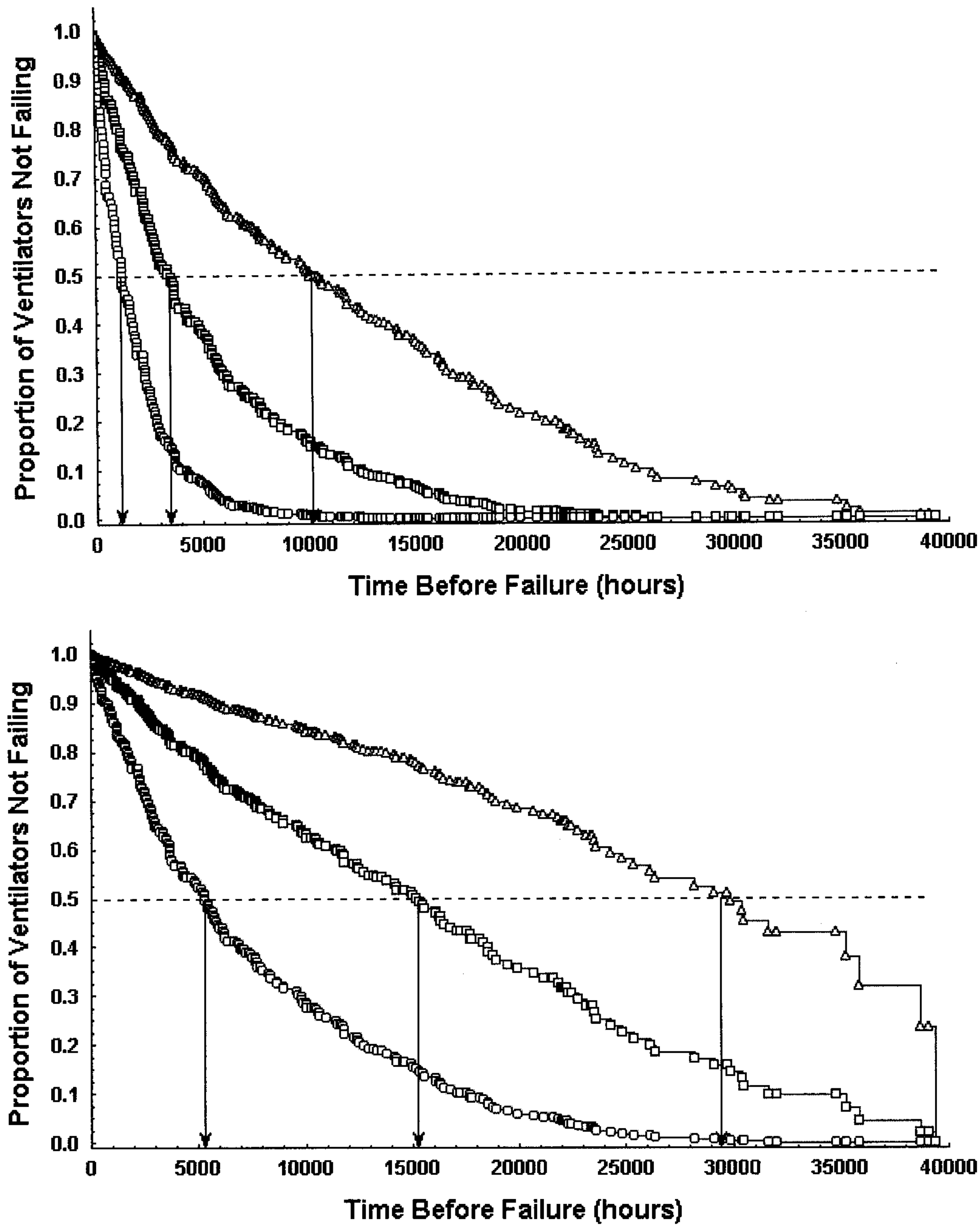

Fig. 4. Two graphs showing the effect on the time before failure made by purchasing ventilators when they are first released for sale compared to waiting several years before purchasing. In each instance the Cox proportional hazard model combined with user-specified values for explanatory covariates were used to graph the predicted time before failure, based on failure data gathered from 66 ventilators used over a period of 9.5 years. The upper panel shows the reliability of a group of the studied ventilators *if* they were purchased when each brand of ventilator was first released for commercial sale. The lower panel shows the reliability of another group of these ventilators *if* they were purchased 10 years after first being released for commercial sale. Each subplot, on both graphs, represents an expected ventilator reliability given a particular set of covariates. In each subplot all explanatory covariates except chronological age and product age were set to the mean values obtained during the study (see Table 3). The dashed horizontal lines demarcate the point at which half of the ventilators have failed. The solid vertical arrows point to the expected hours of use before failure for each subplot. In the upper panel, when the ventilators are new (circles bottom line), both the chronological age and product age are zero. After 5 years of use (squares, middle line), both chronological and product age have increased to 5 years. After 10 years of use (triangles top line), chronological and product age have increased to 10 years. In the lower panel, when the ventilators are new (circles, bottom line), the chronological age is zero but the product age is 10 years. After 5 years of use (squares middle line), chronological age and product age have increased to 5 and 15 years, respectively. When the ventilators have been used for 10 years (triangles, top line), chronological and product age have increased to 10 and 20 years, respectively.

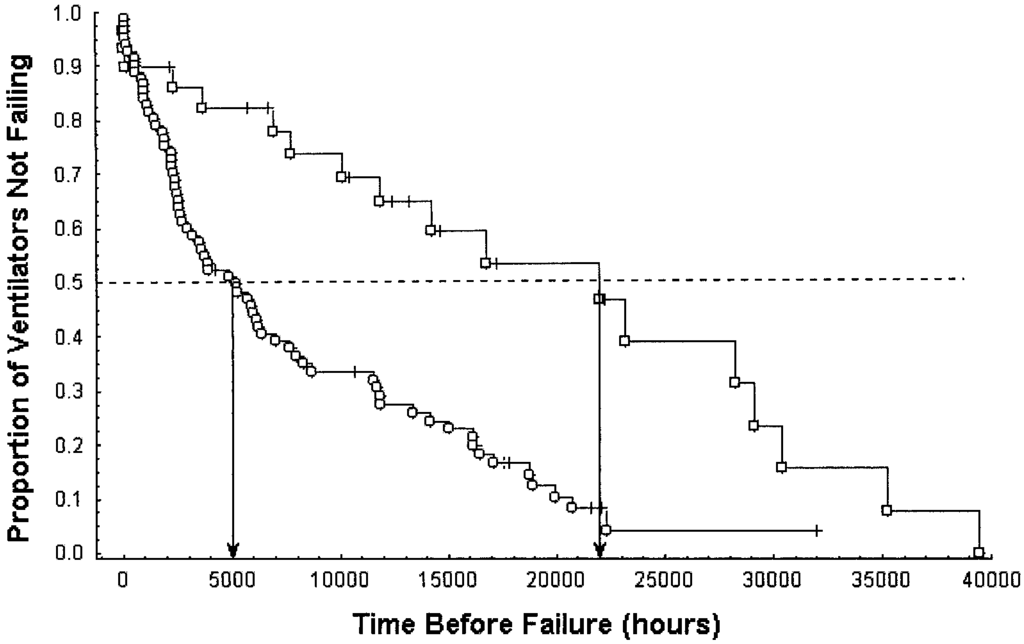

Fig. 5. Time before ventilator failure plotted against the cumulative proportion of ventilators not failing for 2 different groups of ventilators. The dashed horizontal line demarcates the point at which half of the ventilators in either group have failed. The vertical arrows point to the expected hours of use when 50% of the ventilators have failed. The first group (circles, bottom line) comprised 9 Bird 6400ST and 7 Bird 8400STi ventilators used only at a teaching hospital. The second group (squares, top line) comprised 3 Bird 6400ST and 9 Bird 8400STi ventilators used only at a community hospital. The time before failure (survival, top line) was significantly different between the groups ($p < 0.0003$). Censored observations (solid crosses) are represented in each plot.

as a group, these ventilators were safe and reliable regardless of how many times they were previously repaired. Ironically, if we (the consumers) *act* on such information, it would defeat the entire process and create a conundrum. If *everyone* waited for several years before buying a newly released ventilator brand or model, companies would receive no feedback regarding defects and corrective action would be delayed. This would slow product development and greatly impact innovative manufacturers. It would also make products more expensive.

As mentioned, the predictor variables brand and use were judged time-dependent. This finding suggests that some or all of the ventilator brands must exhibit a time before failure that changes as a function of time (use). A breakdown and comparison of the failures by brand, during specific use intervals (see Fig. 2), clearly confirms this hypothesis. For the STAR, VIP, and 6400ST the time before failure was significantly improved at each level of use evaluated. The 8400STi improved so much from the first to second level that the third level was not different from the second. Only the 7200ae showed no significant change in reliability, but there is a plausible explanation for this. Of the 5 studied brands, the 7200ae was the oldest as a product; at completion of the study the 7200ae had been a product for nearly 18 years, compared to 12 years for the STAR and 6400ST and 10 years for the VIP and 8400STi. Possibly, after so many years, engineers at Tyco-Mallinckrodt were asked to focus their attention on developing a new model ventilator (the 840?) or were unable to discover additional improvements that impacted the 7200ae's failure rate.

The average time before unexpected failure for a group of ventilators represents information with many practical uses. For example, consider a facility that uses each of its ventilators an average of 5,000 hours per year and that has a mean time before failure of 9,500 hours. In this hypothetical hospital, each ventilator fails, statistically speaking, approximately once for every 2 years of use. Furthermore, if the average repair costs approximately $1,000,[4] then repairs average approximately $500/ventilator/year. Based on this scenario, a service contract offered at $1,000/ventilator/year[4] no longer seems reasonable. Remember, a service contract should save you money—ostensibly by reducing unexpected repair costs—yet this conjectural respiratory care department would save nearly $500/ventilator/year, by simply foregoing service contracts. Possibly managers purchase these contracts only because they believe ventilators tend to fail more frequently as they age. Based on the performance of the ventilators we studied, however, service contracts represent an insurance policy in reverse: each year you pay the same or higher premiums, yet each year the insured ventilators require fewer repairs.

Another surprising finding was that ventilators used at a community hospital were more reliable than those used at a nearby teaching hospital. This relationship was highly significant when all ventilators were compared and also when only ventilators of the same brand were compared (see Fig. 5). Unfortunately, the study design did not allow me to isolate which factors played the most important role in this finding; nevertheless, such information could eventually provide a mechanism for saving considerable sums of money by replicating the conditions that contributed to the significantly better ventilator reliability at the community hospital.

It is important to note that the 66 ventilators included in this study represent, by definition, a convenience sample. Numbers and variance always strengthen data used for performing regression analysis, so there is little doubt that combining these data with additional data gathered elsewhere would fortify our understanding of ventilator behavior in general.

It is difficult to compare or contrast these data; there are few other scientific studies assessing ventilator reliability. In a related study, I reported significant differences in *average* reliability between the 5 studied brands and speculated that reliability might be improving as a function of time.[7] This study investigates both of these in much greater depth and adds to our understanding of ventilator reliability. Watson and MacIntyre reported that 60 adult ventilators used at their institution experienced 66 failures over a 2 year period (33 failures/year, approximately 0.55 failure/ventilator/year).[3] If we assume similar ventilator use rates, their experience was similar to that of the present study, which saw 226 failures in a 9.5 year period, or 23.8 failures/year (approximately 0.36 failure/ventilator/year). However, when comparing, keep in mind that the definitions of failure used in the 2 studies might not have been identical. Furthermore, some of our ventilators did not participate throughout the entire study (newly purchased ventilators were enrolled as the study progressed), which means that the number of ventilator failures/year may be even closer than they already appear.

Purchasing and maintaining a fleet of mechanical ventilators is an expensive proposition. How often any specific ventilator brand fails has a direct bearing on the long-term cost of ownership, as well as on patient safety. Unfortunately, ventilator reliability is multifactorial and probably changes as a function of time and use. These data indicate that there are variables worth recording that will assist with clinical and financial decision-making regarding mechanical ventilators. Information garnered by combining these data with other data collected elsewhere could eventually allow administrators and clinicians to reduce the risks associated with ventilatory support while concomitantly conserving precious, and seemingly ever-dwindling, health care dollars.

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