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Cost Identification Analysis of Anesthesia Fiberscope Use for Tracheal Intubation

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Abstract

Background

Flexible fiberoptic bronchoscopes (fiberscopes) are often used by anesthesiologists to manage patients with difficult airwaysor for confirmation of proper placement of adouble lumen endotracheal tube. The goal of this study was to determine the incremental cost per patient use, from the hospital's perspective, of a reusable fiberscope for tracheal intubation.

Methods

The fiberscope cost per-use equaled the sum of: 1) annual depreciated capital acquisition cost for the fiberscopes utilized divided by the corresponding number of uses during the study year (10/1/2009 to 10/1/2010), 2) the total annual repair/replacement costs due to fiberscope damage during the study year also divided by the corresponding number of uses during the year, and 3) the incremental costs of cleaning supplies and labor required each time a fiberscope was used.Fixed overhead costs (e.g., hospital endoscope cleaning machinery) independent of the frequency of fiberscope use were not included in thiseconomic analysis.

Results

1,132 fiberscope uses occurred in the 12 months. 14fiberscopes were damaged as diagnosed by a leak test and were replaced by the vendor, foran annualrepair/replacement rate of 1.2% (1 in 81 fiberscope uses). The total cost per fiberscope use equaled $94.95 (range $89.80 - $98.39), which is the sum of $13.75device acquisition (ranging from $8.60 to $17.19 depending on 4 to 8 years of fiberscope lifespan amortization), $13.12 for technician labor, $4.76 for consumables towardsfiberscope cleaning and processing, and $63.32 for fiberscope repairs and replacements.

Conclusions

Repair/replacement costs were the major contributor to the total incremental costs of utilizing reusable fiberscopes in an academic anesthesia department.These results may vary at other hospitals due to differences in purchase and repair arrangements with vendors, clinical practice and fiberscope use, and frequency of damage. When making purchase decisions on these devices, costs downstream from the initial capital monetary outlay need to be assessed.

Introduction

Fiberscopes, sometimes referred to as flexible fiberoptic or endoscopic bronchoscopes, have a lens at one end, an eyepiece at the other, and an imaging bundle composed of several thousand individual fibers. Anesthesiologists use fiberscopes during expected or unexpected cases of difficult airways either via the oropharynx, nasopharynx, or through a laryngeal mask airway to provide direct visualization of anatomy important to aid in tracheal intubation. Fiberscopes may also be used in thoracic surgery procedures to confirm proper placement of double lumen endotracheal tubes (DLTs) placed to achieve periods of lung isolation and single lung ventilation.

Better understanding of how much it costs to deliver different aspects of patient care is needed to properly manage and allocate health care resources [1]. Studies on the economics of flexible optical scopes exist but were performed for bronchoscopy primarily at interventional pulmonology suites performing procedures such as endobronchial biopsy, electrosurgery, laser photoresection, and bronchial stent deployment [2-6]. In contrast, no peer-reviewed analysis of costs incurred from utilizing reusable fiberscopes in a hospital surgical suite has been published.

The goal of this study was to assume the hospital's perspective to determine the incremental cost per patient use of a reusable fiberscope for tracheal intubation. The fiberscope cost per-use equaled the sum of: 1) annual depreciated capital acquisition cost for the fiberscopes utilized divided by the corresponding number of uses during the study year (10/1/2009 to 10/1/2010), 2) the total annual repair/replacement costs due to fiberscope damage during the study year also divided by the corresponding number of uses during the year, and 3) the incremental costs of cleaning supplies and labor required each time a fiberscope was used.

Methods

The cost-identification analysis was performed utilizing clinical use

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data obtained from October 1, 2009 to October 1, 2010 at our university affiliated academic medical center surgical suite with twenty-one main operating rooms and 12 ambulatory operating rooms performing a variety of inpatient and outpatient surgeries on adults. We considered only variable costs (e.g., buying fiberscopes, cleaning scopes, and repairing/replacing scopes) that increase or decreasedepending on changes in the number of fiberscope uses.

Capital costs of fiberscopes

Fiberscope (Olympus, Center Valley, PA, U.S.A.) retail purchase price wasdetermined. The average device lifespan was assumed to be 5 years, which is consistent with the IRS' Modified Accelerated Cost Recovery System (MACRS) depreciation rate [7]. The depreciation was considered a variable cost. The number of times a fiberscope is used is tracked daily using a documentation system completed after each device cleaning.

Cleaning and processing costs

Cleaning and processing included wash cycles consisting of a power flush machine-aided rinse of all ports, manual uni-directional cleaning of all ports with a dual sided brush, repeat wash via the power flush machine, leak tests, high level disinfection cycles within an automated disinfecter machine, compressed air assisted drying, and repackaging and return to the anesthesia workroom.

After analyzing technician work time data, the sterile processing department manager was able to provide an estimate of the technician time required for each step. That time was then multiplied by the hourly compensation of the technician to compute the labor cost of cleaning. The cleaning supplies and materials werealso identified for each step, along with the corresponding actual hospital acquisition cost of each item.

If a leak or other malfunction is detected during cleaning and processing, the fiberscope is still fully cleaned and disinfected before being sent back to the manufacturer for repair/replacement.

The sterile processing department's equipment used in cleaning our fiberscopes, such as the power flush machine and the automated disinfecter, are also used to wash and disinfect all other endoscopes used within the hospital. These include endoscopes from gastroenterology, which are the largest source of used scopes, as well as flexible videoscopic bronchoscopes from pulmonology, and flexible cystoscopesused bythe urology service. This overhead cleaning equipment cost was not included in this analysis as the equipment is shared across several hospital departments.We also did not factor in other fixed costs (e.g., OR nursing director or mortgage costs of the building that houses the surgical suite) as these do not change with the number of fiberscope uses.

Repair costs

Per usual protocol, leak testing of the fiberscope was performed after each use. This assesses the overall integrity of the device by injecting pressurized air and then submerging the fiberscope to look for bubbles. Fiberscopes failing this leak test were designated for repair and sent directly back to the manufacturer. The service contract for the fiberscopes is with the original manufacturer, not with a third party aftermarket vendor.When the manufacturer receives a broken scope a different fully functional new or refurbished fiberscope is immediately shipped back. These repair/replacement fees paid by the hospital on a per repair basis

Hospital acquisition cost of Cidex OPAa per gallon (dollars)	$22.66
Hospital acquisition cost of each single Cidex OPA test strip (dollars)	$0.69
Hospital acquisition cost of disposable gowns (each)	$0.87
Hospital acquisition cost of disposable channel brush (each)	$2.90
Total average amount of Cidex OPA used every 14 days (gallons)	30
Total average number of Cidex OPA test strip every 14 days	784
Total average number of gowns used every 14 daysb	252
Total average number of channel brushes used every 14 days	784
Total average cost of Cidex OPA every 14 days (dollars)	$679.80
Total average cost of Cidex OPA test strips every 14 days (dollars)	$540.96
Total average cost of disposable gowns every 14 days (dollars)	$219.24
Total average cost of channel brushes every 14 days (dollars)	$2273.60
Total average hospital cost of cleaning materials every 14 days (dollars)	$3713.60
Average number of endoscopes cleaned by hospital every 14 daysc	780
Average total cost of cleaning materials per fiberscope (dollars)	$4.76

a: Product info available from: http://www.aspjj.com/us/products/cidex-opa/features-and-benefits
b: 3 gowns per technician, 2 technicians per shift, 3 shifts per day
c: 20,331 endoscopes cleaned by the hospital's centralized sterile processing department during the study's one year period

Table 1: Materials Costs for Fiberscope Cleaning.

Pickup from OR suite and return (hours)	0.083
Leak test, flush, and brush (hours)	0.083
High level disinfection within automated disinfecter machine (hours)	0.250
Air dry and package (hours)	0.083
Paperwork and scanning (hours)	0.083
Total labor time per scope (hours)	0.583
Average total wage per hour of work for sterile processing department technicians (dollars)	$22.50
Total labor cost per scope (dollars)	$13.12

Table 2: Technician Time and Labor Costs for Fiberscope Cleaning.

(with no baseline monthly contract charge) were analyzed.

Sensitivity analyses

Since there is uncertainty on the amortization lifespan of fiberscopes,device costs were also amortized over a low-end range of 4 years to a high end of 8 years to assess the impact on the cost per-use.

Results

Capital costs of fiberscopes

Eight Olympus LF-GP (4.1 mm insertion tube outer diameter) and one Olympus LF-DP (external diameter equal to 3.1mm) flexible tracheal intubation fiberscopes, each with its own attached light sources and eyepieces for viewing, were used during the 12-month study period. The institution previously established this number of fiberscopes sufficient to meet the highest demand days in our surgery suite.

The fiberscope purchase retailprice (includes the light source and eyepiece) equals $8,650 each for a total cost of $77,850.

Using 5 years for the average lifespan of a fiberscope [8], the annual capital equipment cost equals $15,570. During the one-year study period, a total of 1,132 flexible tracheal intubation fiberscopes were used, which equaled 5.6% of all 20,331 endoscopes cleaned by the hospital's centralized sterile processing department.Dividing $15,570by the 1,132 uses during the year equals an average fiberscope capital cost of $13.75per-use. If the fiberscope's life is reduced to 4 years, then the per-use cost rises to $17.19. Conversely, if the fiberscope's life is assumed to equal 8 years, then the cost per-use drops to $8.60.

Cleaning and processing costs

For consumables, the average disposable material acquisition costs for fiberscope cleaning per-use equaled $4.76. (Table 1)

Total technician labor per scope equaled 0.58 hours, with the high level disinfection within an automated disinfecter machine being the most time consuming step. (Table 2) Withthe average wage per hour of the sterile processing department technician equaling $22.50, the average labor costs for fiberscope cleaning per-use equaled $13.12.

Thus, the summed costs of materials plus labor for fiberscope cleaning equaled $17.88 per-use.

Repair costs

A total of 14 fiberscope repair/replacements were required due to a failed leak test found on scope processing during the one-year study. Since fiberscopes were used 1,132 times in the 12 months, and replaced 14 times due to damage, the annual repair rate equals 1.2%.

These 14 fiberscope repair/replacements cost the hospital $5,120 per episode for a total of $71,680, which divided by the 1,132 uses during the one year study period equals $63.32 of repair cost for each fiberscope use.

Total costs

The total cost per-usefor the fiberscope equals $94.95 (range $89.80 - $98.39), which consists of $13.75 device acquisition cost (ranging from $8.60 to $17.19 depending on years of amortization for lifespan of fiberscope), $17.88 for fiberscope cleaning and processing, and $63.32 for fiberscope repairs.

Discussion

An endoscope with fiberopticsfor facilitating placement of a 7.5mm tube in the tracheawas first reported in 1967. [9] Since then, fiberscopes have becomean important and versatile tool in managing patients with complex airways.

Excluding the overhead costs of the sterile processing equipment used to clean all hospital endoscopes (e.g., gastroenterology), the total incremental cost per-use for the fiberscope equals approximately $95 (range $90- $98), which consists of $14 fiberscope device ($9 to $17 depending on years of amortization for fiberscope), $18 for fiberscope cleaning and processing, and $63 for fiberscope repairs.

Our results suggest that repair/replacement costs are the major contributor to the overall costs of utilizing reusable fiberscopes with acquisition and cleaning costs making a smaller impact. Fiberscopes are complex instruments with delicate mechanical, light source, and fiberoptic components. A failure of the leak pressure test indicates a defect in some part of the device though it does not specify the exact location or cause of the problem. Data on fiberscope repair rates are not available, but we found the annual repair rate to equal 1.2% of total uses. In other words, on average the fiberscope will be used 81 times before being sent for repair/replacement.

The ability of the fiberscope to conform to the patient's airway anatomy offers benefits but also lead to damage. The device's lifespan, and therefore cost per-use, will differ by the facility depending on factors such as the caseload, nature of clinical use, user skill, and usage of scopes by trainees in an academic training program. Our results assume equal wear and tear of fiberscopes from various clinical uses. However, it is not known if more damage occurs for fiberscope use in DLT cases (due to the inherent rigidity of DLTs and their narrower inner lumens), or in complex and difficult airway cases (e.g., the possibility of the patient biting on the scope), or in refurbished scopes as compared to new scopes. Some centers may perform more DLT insertions such that a hospital's mix of these characteristics may affect overall costs. We also did not perform an analysis of fiberscope use for pediatric cases as children are anesthetized in a different facility.

Since repair and replacement costs paid by our facility were approximately two thirds of the $95 fiberscope cost per-use, interventions that reduce the number of times reusable fiberscopes have to be sent for repair are likely to have the most effect in reducing fiberscope costs. For example, training programs that promote safe scope use have been shown to decrease the number of episodes of scope repairs [3,10]. At our institution, we have recently implemented safety procedures aimed to decrease the risk of damage, including educating practitioners about costs and risk of damage as well as installing a wall-mounted cabinet in the anesthesia workroom to properly protect fiberscopes when not in use.

These are useful data, as practitioners may not appreciate that each fiberscope use is associated with almost $100 of actual cost to the hospital. When deciding to purchase these devices practitioners need to keep in mind downstream costs after the initial capital outlay.

The sum of $95 per fiberscope use does not represent the fiberscope related billing charges sent to the insurance company by the hospital for payment. Although hospitals do know exactly what the charges on the patient's hospital bill are, charge data do not usually reflect the true cost to the hospital of providing a particular intervention [11]. As a result we undertook this study from the hospital's perspective. Costs estimates will be different if taken from the point of view of the patient, payer, or society as a whole.

Our costresults may not be generalizable to other facilities. For example, service contracts may affect overall fiberscope costs. Although manufacturer service contracts may be fairly standardized in terms of pricing, third party aftermarket service companies are available and each facility needs to assess the repair services and prices offered by each of these vendors. For example, certain service contracts, such as the one at our institution, allow facilities to quickly receive a new fiberscope in exchange for a damaged one. Alternatively, service contracts may provide no continual immediate exchange for broken fiberscopes which would also require facilities to possess more fiberscopes to substitute for ones that are out for repair.

Our results may also not apply to surgical suites that use fiberscopes relatively less often. For example, had the same number of fiberscopes been available but the frequency of use cut in half then the fiberscope cost per-use would increase to $109. This is because a rise incapital fiberscope expense would result from being divided by fewer uses. Conversely, less frequent use would likely result in proportionately less damaged scopes so the repair/replacement cost per-use would stay likely stay constant.On the other hand, more or less frequent fiberscope use wouldn't change the incremental cleaning costs per-use at our institution.However, at different facilities, expectedfiberscope-cleaning costs could be higher or lower than the $17.88we estimated. This value could vary for example depending on whether a hospital had the specialized cleaning equipment available directly in the surgical suite for scopes used in the operating rooms, rather than a centralizing endoscope-cleaningsite,as is the case at our institution.

Lastly, our cost-identification analysis does not attempt to determine the value of the fiberscope (e.g., costs versus clinical benefits) or compare it to other airway management techniques. For example, this study also did not examine the economics of reusable flexible tracheal intubation videoscopes, which contain a charge-coupled device chip so that the image is electronically generated and displayed on a color monitor. This provides a higher picture quality and at times a broader field of view than fiberscopes. Flexible tracheal intubation videoscopes have a higher acquisition costs than fiberscopes. For example, the Olympus BF-3C160 videoscopic flexible bronchoscope has a list price of $26,500, which does not include required operating accessories such as a video processor (Olympus list price $23,500), light source (Olympus list price $13,400), video monitor (Olympus list price $7,800), and cart (Olympus list price $3,650 plus $1,075 for monitor swing arm) [12]. Additionally, flexible intubation videoscopes are also generally more expensive to repair than their fiberscopic counterparts. Thus, for facilities utilizing reusable flexible videoscopes for tracheal intubation, a separate economic analysis is warranted.

Airway device technology is also continually advancing with new products available to the clinician. For example, videolaryngoscopy may change how often fiberscopes are used. Furthermore, although fiberscopes have traditionally been multi-use, newer disposable flexible tracheal intubation videoscopeshave recently been introduced [13]. These newer devices will also require a separate economic analysis.

Anesthesiologists use fiberscopes in a variety of situations such as difficult tracheal intubations, changing an endotracheal tube, diagnosis of upper airway pathology, examining the tracheobronchial tree, and confirmation of DLT placement. Repair/replacement costs were the major contributor to the total incremental costs of utilizing reusable fiberscopes in an academic anesthesia department. These results may vary at other hospitals depending on the facility's purchase and repair arrangements with vendors, clinical practice and number of fiberscope uses, and frequency of damage. When making purchase decisions on such devices, downstream costs after the initial capital monetary outlay need to be assessed.

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