

# The cost of an upper gastroduodenal endoscopy: An activity-based approach

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The cost of medical procedures is often unknown, but is nevertheless crucial for setting reimbursement and health care policies. The cost of an upper gastroduodenal endoscopy was investigated in ambulatory adults in a large academic hospital in the province of Quebec, from the perspective of the hospital.

An activity-based costing methodology was used to break down the procedure into a number of priority tasks, to which resources used at the department level (labour, equipment, materials) were allocated. The direct cost of performing an endoscopy ranged from \$62 for an unsedated, unbiopsied patient to \$89 for a sedated, biopsied patient. Not included in this amount were separate reimbursement fees of \$15 for biopsy analysis and the \$50 professional fee for the performing physician, which are charged

directly to the Ministry of Health.

Incorporating overall, general hospital fixed overhead costs raises the cost of the procedure substantially, by \$41, as does the use of nonreusable biopsy forceps, which adds about \$63 to the total cost of the procedure.

Given the high proportion of overall, hospital-wide, overhead costs in the total cost of the procedure, allocation methods of these overhead costs in current hospital accounting systems should be improved to obtain a more precise estimate of the full cost of upper gastroduodenal endoscopy.

**Key Words:** *Activity-based cost; Cost; Endoscopy; Gastroduodenoscopy; Quebec*

*Résumé à la page suivante*

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## Coût des endoscopies digestives hautes : méthode d'évaluation par activités

**RÉSUMÉ :** Le coût des interventions médicales est souvent inconnu, mais il est quand même nécessaire à l'établissement de politiques en matière de remboursement et de soins de santé. Nous avons donc tenté de déterminer le coût des endoscopies digestives hautes pratiquées chez des adultes ambulatoires dans un important centre hospitalier universitaire de Québec, et ce, du point de vue de l'hôpital.

Nous avons eu recours à une méthode d'établissement des coûts par activités pour diviser l'intervention en un certain nombre de tâches prioritaires pour lesquelles des ressources avaient été accordées au service (personnel, équipement, matières). Le coût direct de l'endoscopie variait

de 62 \$ pour les interventions sans sédation ni biopsie à 89 \$ pour les interventions avec sédation et biopsie. Étaient exclus de ces chiffres des frais distincts de remboursement de 15 \$ pour l'examen du prélèvement et des honoraires de 50 \$ versés au médecin qui avait effectué l'intervention, sommes réclamées directement au ministère de la Santé.

Le fait d'inclure les frais fixes, généraux de l'hôpital accroît sensiblement le coût de l'intervention, soit de 41 \$, tout comme le coût des pinces à biopsie non réutilisables, qui ajoute à peu près 63 \$ au coût total de l'intervention.

Compte tenu de la forte proportion des frais généraux dans le coût total des interventions, il faudrait améliorer les méthodes de ventilation des frais généraux dans les systèmes actuels de comptabilité des hôpitaux pour obtenir une évaluation plus précise du coût réel des endoscopies digestives hautes.

Because of the growing number of economic evaluations of peptic ulcer disease (1-4), accurate costing of diagnostic procedures such as upper gastroduodenal endoscopy (UGE) has become necessary. Depending on the chosen perspective, using charges (official prices that are charged by the health care provider to the health care payer) or reimbursement fees in the analysis may be sufficient. However, from the perspective of the health care provider (hospital or private practice), charges do not represent an accurate estimate of the cost borne by the provider.

As well, in many health care financing systems, such as in Canada, hospitals are financed by a global budget, and reimbursement fees are not available for in-hospital procedures (except for the physician's fee).

Cost estimates of procedures can, therefore, be useful in several ways – to help in the budgeting exercises of gastroenterology departments based on expected patient flows, to help set realistic billing prices for patients who are not covered by the local health system, to avoid cross-subsidization by other patients undergoing other procedures and to provide a sound basis for the economic analysis of therapies.

Only a few cost estimates of UGE have been published, most of which have covered only some aspects of the whole endoscopy procedure, such as cleaning and disinfection (5-10).

### STUDY OVERVIEW

The present research originated as part of a larger project on the cost effectiveness of the medical management of dyspepsia. Given that no reliable or official estimates of the cost of endoscopy could be found for Canada, and especially for Québec, a detailed cost analysis was performed in one large general hospital in the province of Québec. This research was undertaken during 1998, through a series of visits at the gastroenterology department of the Montreal General Hospital, Québec, that combined observation of actual endoscopies being performed, detailed interviews with staff, and collection of the accounting and purchase data from the department and various other hospital departments (accounting, maintenance), and of annual

official reports to the Québec Ministry of Health (Report AS471).

The primary perspective was that of the hospital administration. The intent was first to develop a direct cost estimate at the departmental level and then to extend this estimate to the hospital level.

Costs at the department level were divided into direct costs and department overhead costs. To gain insight into the process, a detailed list of activities was made, and direct costs were allocated to each activity.

Costs were divided into three components: labour; supplies and materials; and equipment, including repair and maintenance. Each cost component was also labelled as either variable costs, ie, costs linked directly to the number of procedures performed such as labour or supplies, or fixed costs (equipment and part of maintenance).

### METHODS

#### Definitions and costing methodology

A distinction is generally made between microcosting approaches, whereby each component of resource use is estimated and a unit cost derived for each in a bottom-up approach, and more macrocosting approaches, in which the focus is on (less precise) average costs per patient, per diem or per stay (11).

With a microcosting approach, it is, therefore, necessary to identify the component parts of the procedure and to find a unit price for each component. As such, microcosting is an ideal candidate for applying an activity-based costing approach because the procedure can be broken down into a series of independent steps (activities) (12). The drawback of this method is the heavy workload needed for a detailed assessment. However, its power lies in a more accurate measure of overhead and related costs, and a more precise allocation of these costs.

In conducting costing exercises of medical procedures, a useful distinction can be made among primary activities, which concern the actual execution of the procedure (often involving direct patient contact such as the scoping itself); secondary clinical activities, which either precede or follow the actual procedure (ie, patient preparation); and support

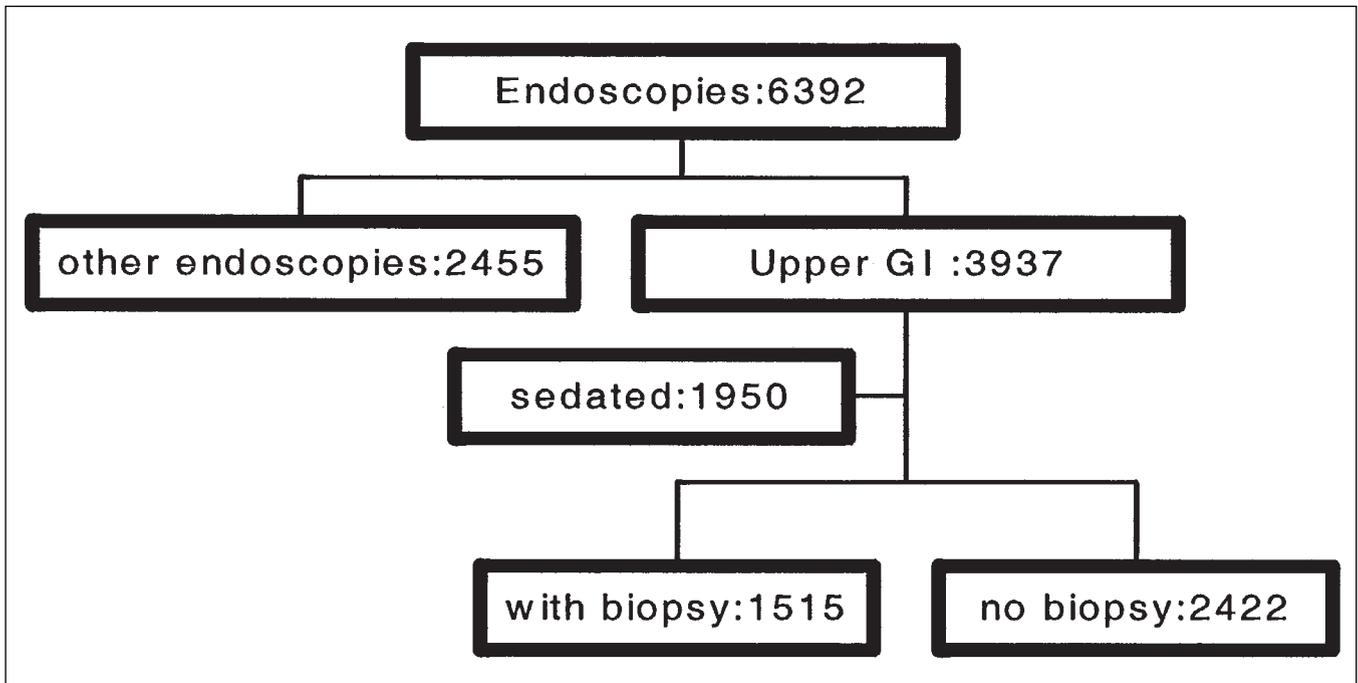


Figure 1) Throughput within the gastroenterology department of the Montreal General Hospital, Quebec, in 1998. GI Gastrointestinal

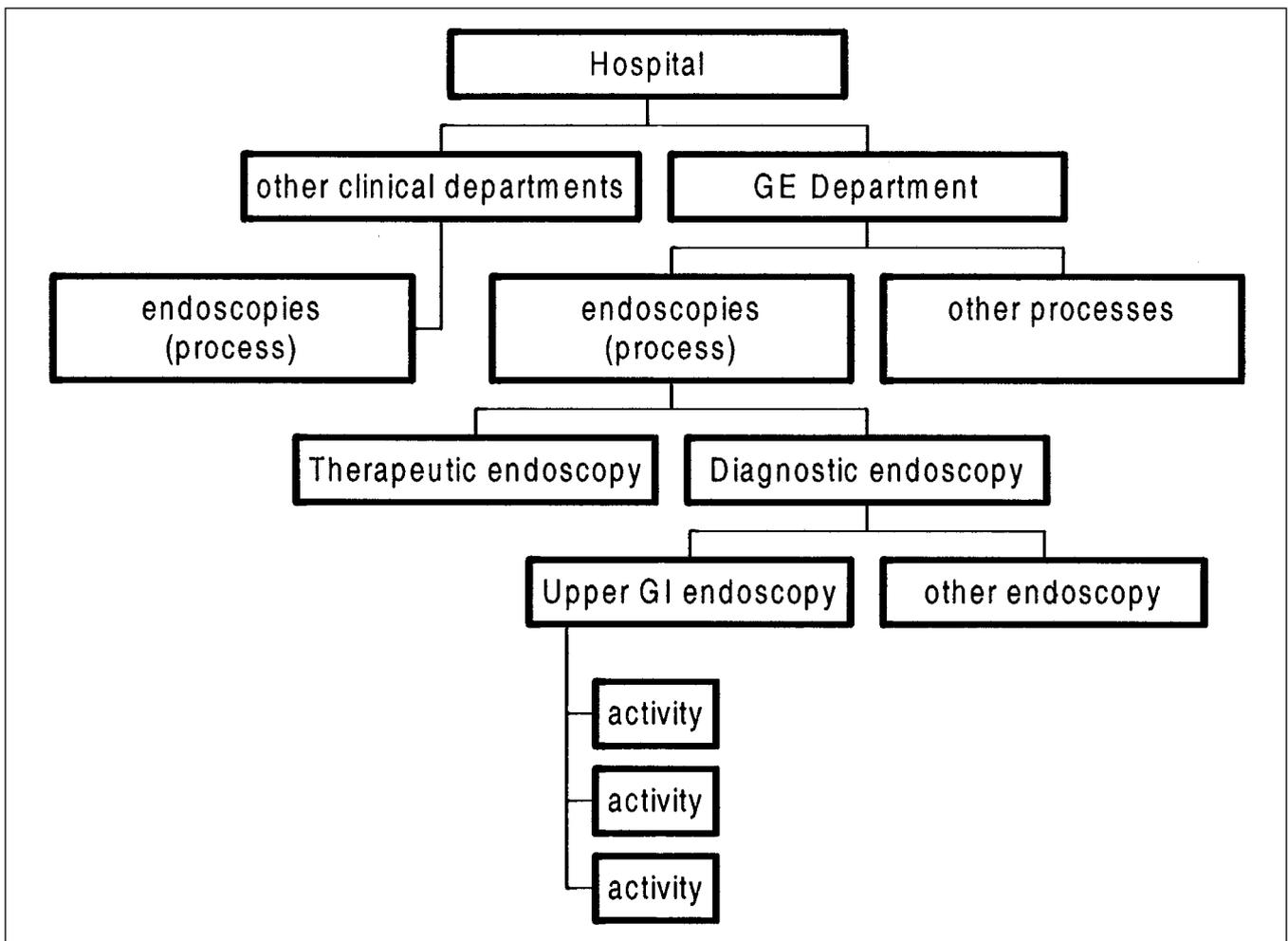
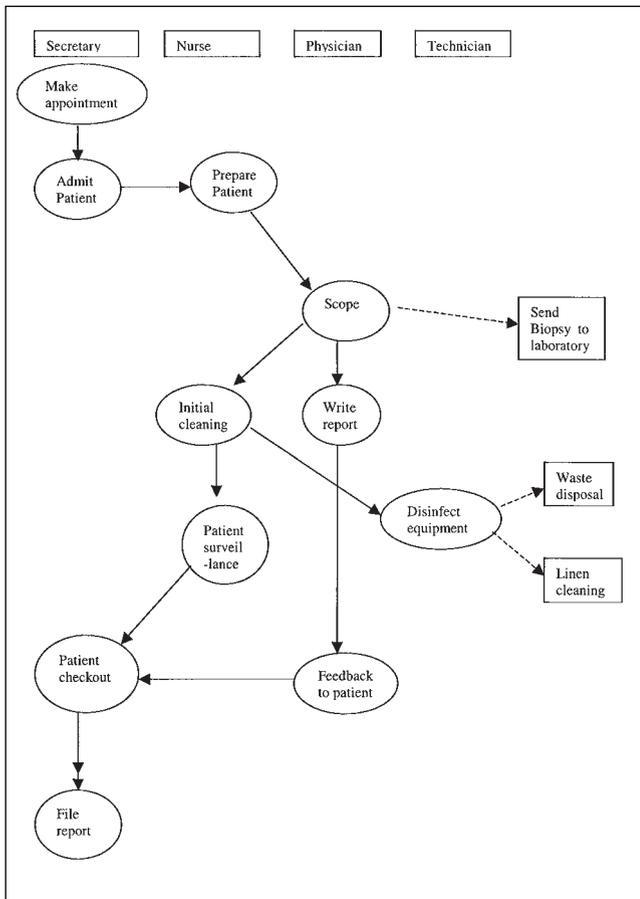


Figure 2) Definition of the process levels for endoscopy. GE Gastroenterology; GI Gastrointestinal



**Figure 3)** Activity map of endoscopy performed at the gastroenterology department of the Montreal General Hospital, Quebec

activities. Support activities can be further divided into specific support related to the procedure at the department level (ie, maintenance of endoscopy equipment) and general hospital-wide support activities, ie, general overhead costs (such as providing parking spaces for patients).

Incorporating primary and secondary activities, and specific support activities into the costing exercise provides a direct cost estimate of the procedure, while incorporating general overhead costs provides a full cost estimate from the provider's perspective.

### THE SETTING

The gastroenterology department where this study was conducted is part of a general teaching hospital in a large urban area in the province of Quebec (Montreal General Hospital).

Endoscopy activities were distributed in 1998 as shown in Figure 1. Of all the diagnostic endoscopies performed in the department, about 62% were UGD endoscopies, of which approximately 38.5% were performed with biopsy. Close to one-half (49.5%) of all the UGD endoscopies were performed with the patients sedated; patients recovered in the recovery room after the procedure. Other endoscopies performed were lower diagnostic gastrointestinal endo-

scopies and therapeutic endoscopies. The volume and shares of the different types of endoscopies are quite stable from year to year. The procedure was defined as upper gastroduodenal diagnostic endoscopy for (mainly) ambulatory patients. A general activity chart was drawn of the whole procedure, which was considered to be a single subprocess within the gastroenterology department (Figure 2).

It should be mentioned that endoscopies, as a process, are not specific to the gastroenterology department; other clinical departments (ie, pneumology, pediatrics) also conduct endoscopic procedures. Other types of endoscopies (sigmoidoscopy, colonoscopy, etc) are also performed in the gastroenterology department, often using the same or parts of the same equipment (joint use). Therefore, endoscopy in the present article refers only to endoscopy of the upper gastrointestinal tract (esophagogastroduodenal) for exploration and diagnosis.

The endoscopy process was further broken down into a set of independent activities that provided the framework needed to identify the resources used at each step of the procedure (Figure 3).

For example, patient preparation includes explaining the procedure, asking about antecedents, measuring arterial tension and administering sedation, if necessary, plus some general counselling, and providing help and transport to the endoscopy room.

For each activity defined in Figure 3, the resources used were compiled and divided in four categories: labour (time), equipment, maintenance and repair, and consumables. An additional, separate resource is the (capital) cost of facilities devoted to endoscopy.

Labour and consumables were considered to have variable costs, with the visit as the cost driver, while equipment and some repairs were considered to have fixed costs (see details below). (The analysis was first conducted over a fixed volume of procedures per year, which was then relaxed.)

Labour includes the time spent by a secretary booking appointments (15 min); the nurse's time for patient preparation, assistance during scoping, check-in and -out, and monitoring (20 min); technician time for cleaning (20 min); and porter time for transferring patients to and from the recovery room (10 min).

### COSTING METHODS

#### Apportioning the joint use of the equipment within the gastroenterology department

A number of expenses from the gastroenterology department were allocated to UGE using the share of UGEs (Appendix 1). These expenses are for secretary time dedicated to endoscopy bookings, peripheral endoscopy equipment (light source, video monitor, colour video printer, trolley for equipment transport), stretcher, and the purchase and repair of the pulse oxymeter.

UGE visits accounted for only 18.4% of the total number of all scheduled visits, whatever their purpose, to the gastroenterology department, but accounted for 61.6% of

all endoscopies, 55.7% of all the endoscopes cleaned and 43.9% of the pulse oxymeter use for sedated patients.

**Calculation of capital and repair costs**

Capital expenses for equipment were annualized over their economic lifespan by using the following formula (13):

$$\text{Annual equivalent expenditure} = K \cdot IC / [1 - 1 / (1 + IC)^J]$$

where K is the purchase cost of the equipment, IC is the inflation-corrected interest rate ( $IC = 1 + I / 1 + CPI = 3.4\%$ ), which is the opportunity cost of the invested capital, I is the interest rate, CPI is the consumer price index and J is the economic lifespan of the equipment in years. J was set at seven years for endoscopic equipment and 10 years for trolleys and stretchers.

Repair and maintenance costs are based on a fixed contract per year for the endoscopes, and was set at 5% of the purchase value for other electronic equipment and at 3% for nonelectronic equipment because detailed billings for the repair of specific equipment were not available.

Annualized equipment expenditures were calculated for each piece of equipment in use and allocated over the different activities on a per procedure basis.

No allowances were made for the building costs of the facilities themselves. Given the age of the building (over 30 years), full depreciation was assumed, although repair and maintenance of the endoscopy facilities were allocated based on the general hospital-wide cost account by using a direct allocation per square meter. Based on a construction cost of \$1600/m<sup>2</sup>, a total surface area of 110 m<sup>2</sup> and a depreciation time of 30 years, building costs would add another \$2.40 to each procedure (for a volume of 4000 procedures per year).

**Department-specific overhead costs**

Some costs were already apportioned by the hospital accounting system to the gastroenterology department. These costs were then further allocated to UGE, by using the share of patient visits (18.4%) as the allocation key, and then further allocated to each activity.

**Hospital institutional overhead costs**

To arrive at the full cost of a UGE visit from the perspective of the hospital, it is not enough to consider only procedure-related costs, because wide, indirect support is also given by the other hospital departments, such as the administration, cleaning and maintenance departments.

In an ideal accounting system, hospital-wide overhead expenses would have been allocated by the accounting system to every department (considered as a cost centre), taking into account overhead interdepartmental cross-flows. (This is best done using a simultaneous equations approach, [14].) For the present study, however, such detailed accounting was not available. Therefore, a direct allocation method was used instead.

Another question is which hospital-wide overhead costs should be allocated to a specific procedure, such as ambulatory endoscopy.

An extreme view would be to allocate all types of overhead, first to the clinical departments or patient-oriented centres, and then in a second step to allocate costs in each department to the specific procedures performed in the department.

This approach can, however, be criticized on two counts. First, not all general, hospital-wide overhead expenses are related to an endoscopy visit (ie, meals, lodging, ambulance transport); therefore, it would not be fair to add these expenses to the cost of an endoscopy, because endoscopy patients do not use such resources.

Second, it would be better, and in the spirit of activity-based accounting, to allocate general overhead costs (ie, library) directly to the activity based on some direct specific criterion (say the number of books ordered or borrowed by endoscopy personnel, which is the real cost-driver) rather than on some general allocation key.

At the general level of the hospital support activities, a distinction can be made between patient-related and non-patient-related activities (ie, nursing administration, or patient reception or billing administration versus general maintenance or security), and a specific cost driver linking each activity to endoscopy can be derived.

As a (imperfect) compromise, for the present study, expenses related to meals, medical transport, special services and personal expenses were excluded from the hospital-wide support activities, and the other overhead expenditures were retained as they appear in the official yearly financial hospital report (document AS471) submitted each year to the Provincial Ministry of Health. Teaching charges and residents' costs were also excluded because these are supported by sources other than the hospital budget.

All remaining hospital overhead costs were regrouped into three headings: administrative activities, clinical medical support activities and technical activities (repair and maintenance).

**RESULTS**

Table 1 shows the breakdown of the direct cost per procedure, based on a volume of 4000 procedures per year. This cost excludes department or general hospital overhead costs.

There is a clear difference between the costs of sedated patients and the costs of nonsedated patients, which can be tracked mainly to the cost of medication, and of the nurse's time for patient preparation and surveillance.

Sedation costs occur mainly during preparation of the patient and during recovery; the cost of equipment was nearly identical for sedated and nonsedated patients.

UGE patients in recovery account for an average of 19% of all patients in the recovery room. These patients require a pulse oxymeter and cardiac monitor, and have their tension controlled manually by a nurse. The average time spent in the recovery room is approximately 15 min, after

**TABLE 1**  
Direct average cost of an endoscopic procedure at the Montreal General Hospital, Quebec

Activity	Labour (CDN\$)*	Supplies (CDN\$)	Equipment† (CDN\$)	Facilities‡ (CDN\$)	Total (CDN\$)
Patient appointment and administration	4.14	\$	\$	–	4.14
Patient preparation					
Unsedated	1.80	1.30	–	–	3.10
Sedated	4.72	14.95	–	–	19.67
Performing endoscopy					
Unsedated	1.80	0.80	36.63	–	39.23
Sedated	1.80	0.80	36.94	–	39.54
Biopsy¶	–	6.58	–	–	6.58
Cleaning and disinfection	4.85	2.71	5.84	–	13.40
Sedated patient recovery	1.80	1.51	0.24	–	3.55
Total					
Unsedated no biopsy	12.59	4.80	42.47	0	59.86
Sedated with biopsy	17.31	26.55	43.02	0	86.88

\*Nursing, technician and secretarial time, excluding physician time; †Including repair and maintenance of equipment and fees; ‡Existing facilities construction costs were deemed fully depreciated; §Included in departmental overhead costs calculations; ¶Excluding laboratory fees

**TABLE 2**  
Department-specific overhead cost allocation at the Montreal General Hospital, Quebec

Activity	Item	Total cost (CDN\$)	Unit cost per endoscopy (CDN\$)
Appointments and administration	Courier	2,743	0.13
	Computer expenses	2,010	0.09
	Telephone, postage, pagers	7,208	0.34
	Administration expenses	14,198	0.67
Endoscopy examination	Disposable linen and housekeeping supplies	153	0.01
	Medical literature	1,131	0.23
Patient recovery	Transport	1,131	0.05
Nonspecific activities	Maintenance and electricity supplies	1,243	0.06
	Various purchased services	5,092	0.24
	Miscellaneous expenses	3,729	0.17
Total			1.99

which time, patients are transported back to the gastroenterology department, where they stay for another 15 to 30 min before getting dressed.

The total direct cost of a UGE varies between \$60 for nonsedated and \$87 for sedated biopsied patients, to which \$50 needs to be added for the physician's fees, which are charged directly by the physician to the provincial insurance scheme (Regie de l'assurance maladie du Québec). In addition, \$15 needs to be added for the processing of the

biopsy sample by the laboratory. (From a purely hospital administration perspective, these costs should be left out as they are not borne by the hospital.)

On top of this cost, a small amount should be added for departmental overhead costs (approximately \$2) (Table 2).

Overall hospital-wide overhead costs, allocated on a per admission basis, yielded \$1.60 for administration, \$22.54 for general support activities and \$17.03 for technical activities, adding a total fixed cost of \$41.24 per endoscopy.

**TABLE 3**  
**Total cost per endoscopy (excluding laboratory and physician fees) at the Montreal General Hospital, Quebec**

	Nonsedated patient (\$CDN)	Sedated patient (\$CDN)
Direct cost	59.86	86.88
Indirect departmental cost	1.99	1.99
Indirect hospital cost	41.24	41.24
Total	103.09	130.11

These costs, however, exclude the cost of the facilities ( $\pm 110 \text{ m}^2$ ), which was considered amortized. No allowance was made for the idle time of personnel between endoscopy activities. When added together, these costs give a total direct cost per procedure from the hospital perspective (Table 3).

If the \$15 reimbursement fee is assumed to be representative of the true cost of the laboratory analysis of the biopsy specimens and includes physician fees, the total costs per procedure from a health care system perspective, including physician fees, ranges from \$153 for a nonsedated, non-biopsied patient to \$195 for a sedated, biopsied patient.

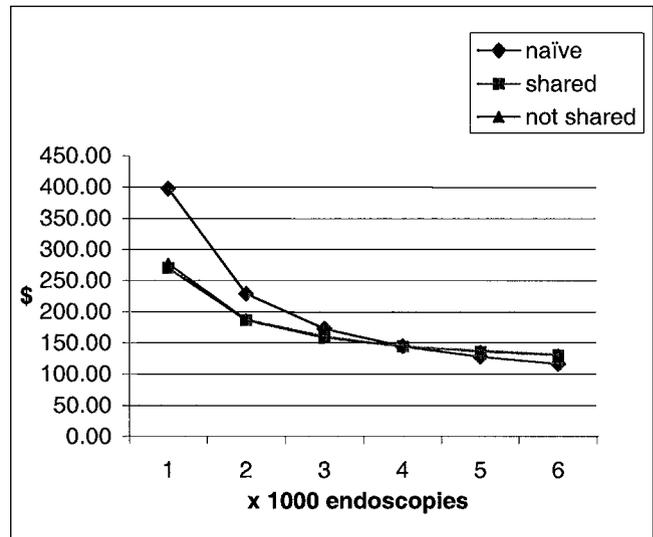
**ENDOSCOPY COST-VOLUME FUNCTION**

Given the high share of indirect hospital-wide overhead costs (about one-third) and the large share of fixed costs (equipment and labour), it is interesting to draw a cost-volume curve of the average unit cost per endoscopy (Figure 4) when the number of procedures performed varies.

In the short term, labour (ie, nursing and technician time) is fixed and does not vary much, unless there is overcapacity. The same can be said of the equipment. However, when the patient volume increases above some threshold, existing factors are fully used, and new personnel need to be hired and additional equipment purchased.

Whether the equipment will be shared for other endoscopic procedures within the hospital or department (as is the case in the present study), or whether it should be dedicated only to UGEs also needs to be determined. The following three scenarios were investigated in the present study.

- A 'naïve' approach, whereby no new equipment is purchased or discarded as the number of procedures changes, but personnel time is considered variable. Fixed costs are only adapted in relative proportion to the number of procedures performed. For example, a decrease from 4000 to 3000 procedures per year would reduce unit fixed costs by 25%.
- A 'shared' approach, whereby additional equipment is shared for other endoscopic procedures based on the current observed ratio, ie, equipment is considered divisible.



**Figure 4)** Cost-volume function of upper gastrointestinal endoscopy

- An 'unshared' approach, whereby all the equipment is dedicated solely to UGEs, but the current staff levels and equipment density per 1000 endoscopies are the same as those observed in the study. However when the volume of procedures (ie, patients treated) increases, additional equipment has to be purchased only for UGEs (labour is considered variable).

Overall hospital overhead costs were considered fixed in all three scenarios because it was thought that the level of overall hospital expenditures would not be influenced significantly by an increase in the number of endoscopies.

The 'naïve' approach tends to overestimate the overall cost per procedure (Figure 4), especially for volumes below 3000 per year (starting from a situation of 4000 procedures per year), while in the present study, results of the shared and unshared strategies were very close, mainly because the additional purchase of equipment for UGE only in the unshared scenario is small. For example, for a volume of 5000 endoscopies per year, the use of a mavograph is equal to 1.5 in the shared scenario (with two installed in the department) and 2 in the unshared scenario.

Looking at the unit cost structure of a UGE in the shared scenario, it can be seen that overall hospital overhead costs account for a non-negligible part of the overall unit cost (about one-third) but rise quickly when volumes fall (Figure 5).

If, however, all biopsies are performed with nonreusable forceps (at \$70 each), compared with only a minority in the present series, then the variable cost and the overall unit cost increase significantly (Figure 6).

**DISCUSSION**

Only a few cost studies of UGE have been published, mainly from the United States and France, but several have covered only part of the cost of a typical procedure.

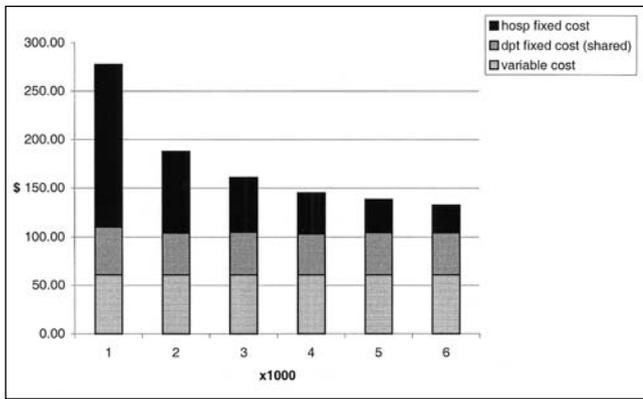


Figure 5) Cost structure of upper gastrointestinal endoscopy (shared equipment) at the Montreal General Hospital, Quebec. dept Department; hosp Hospital

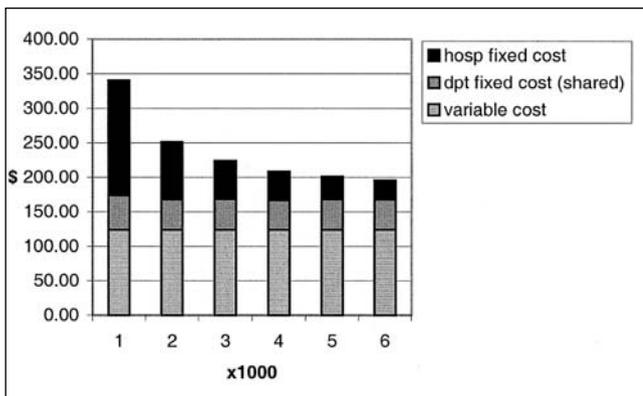


Figure 6) Cost-volume structure of upper gastrointestinal endoscopy (shared equipment) with nonreusable biopsy forceps. dept Department; hosp Hospital

Among the earliest published figures for flexible endoscopy costs are those by Showstack (15) from the United States. These figures were based on one full-time physician, plus a nurse and part-time secretary working in four rooms. A markup for general overhead costs of 20% of functioning costs (salary, equipment and materials) was added.

In the study by Showstack and Schroeder (15) depending on the volume of activity (between six and 12 endoscopies per day for a 230-day working year), the cost per procedure in 1977 ranged from US\$83 to US\$41. Total time per endoscopy was assumed not to exceed 45 min.

A second, but much criticized, French study by Ruzsniwski and Bernades (11), made a distinction among three settings – public hospital, private hospital and private office – with an average cost of Fr 677, Fr 1667 and Fr 880, respectively, in 1991. These costs were assessed by André (12), whereby a distinction was made according to biopsy, sedation and 24 h hospitalization (Table 4).

French data collected prospectively by Martin and colleagues (16) in 1992 in a single public hospital gastroen-

TABLE 4  
Cost of endoscopy in public and private hospitals in France in 1993

	Public hospital (Fr)	Private hospital (Fr)	Private practice (Fr)
No sedation, no biopsy	490	496	496
No sedation, plus biopsy	760	820	820
Sedation plus biopsy	1499	2737	–

CDN\$1 = approximately Fr 5. Data from reference 12

TABLE 5  
Overall cost structure per endoscopy in a French hospital in 1993

	Cost (Fr)	% of total
Salaries, including physician	207	57
Equipment	45	12
Consumables	46	13
Overall overhead costs	64	18
Total	361	100

CDN\$1 = approximately Fr 5. Data from reference 18

terology department gave a mean time of 15 min for the endoscopist, 29 min for a nurse and 19 min for a secretary, to which one should add 7 min for an anesthetist in case of sedation, 22 min additional nurse time and 20 min for patient transport to and from the examining room.

The total cost, including personnel salaries, equipment, consumables and overhead costs, of the entire procedure yields a mean of Fr 895 (approximately CDN\$179) with sedation and Fr 361 (approximately CDN\$72) without sedation. Biopsy costs (33% of all cases) of Fr 216 (approximately CDN\$43) should be added in case of biopsy. The overall cost structure is provided in Table 5.

Urayama et al (10) studied the use of a combination of 44 gastrointestinal endoscopes between 1989 and 1995, of which nine were duodenoscopes (diagnostic and therapeutic) and 13 gastroscopes. His study covered the purchase, repair and per-use cleaning (including technician time and cleaning materials). Other equipment (light sources, video processor), pharmaceutical supplies and personnel costs related to the procedure itself, admission and recovery were omitted from the study, as were indirect costs (rent, insurance, etc).

Purchase costs of duodenal endoscopes ranged between US\$12,000 and US\$17,900 (mean US\$14,060), with a useful lifetime between 2.9 and 10.4 years (mean 6.3 years), yielding a per-use cost of US\$49.15 (range per endoscope US\$32.15 to US\$89.66).

Remarkably, the average repair costs over the lifetime of the endoscopic equipment equaled its purchase cost, with a mean expenditure of US\$13,233 (range per endoscope US\$877 to US\$26,509).

In total, with a cumulative mean use per endoscope of 723 procedures per year (range 275 to 1360), the average (partial) cost per procedure amounts to US\$45.10 (range US\$20.97 to US\$70.84). The authors recognized, however, that they omitted a large portion of additional costs, such as personnel costs related to the procedure itself, the cost of related equipment and indirect costs.

A much more detailed cost estimate of pediatric endoscopy in a single institution was presented by Kesteloot and colleagues (13), with a separate accounting of variable costs (including labour), and fixed equipment and overhead costs, including facilities, in a sample of 10 patients.

Endoscopy procedures were classified into upper and lower diagnostic procedures. Equipment costs included initial purchase of the endoscopes, monitoring and reanimation equipment, transformed in annual equivalent fixed cost. Additional fixed costs for space were estimates at 50 m<sup>2</sup> occupied at 20% at the cost of 197.5 ECU/m<sup>2</sup> (approximately CDN\$15), including utilities such as heating and electricity. It was assumed that other ancillary equipment (light sources, video monitor, disinfection) were already available for adult endoscopy and, therefore, usable at no cost.

Labour time per procedure, including surveillance, amounted to 105 min for the nurse's time and 16 min for the pediatrician.

The base-case analysis corresponded to 200 procedures per year, but simulations up to 600 were performed (with additional purchase of equipment). Variable costs per procedure amounted to 96 ECU (approximately CDN\$125) for an upper diagnostic endoscopy procedure, with fixed costs estimated at 11,985 ECU per year. The average unit cost per UGE procedure decreases from 296 ECU (approximately CDN\$385) for 100 procedures per year to 130 ECU (approximately CDN\$169) for 600 procedures per year.

These cost estimates for pediatric endoscopy may overestimate the true cost because the average lifetime of the equipment was set at five years, which is relatively short, and interest rates were rather high at 10%. Longer lifetime and lower interest rates were shown to decrease the annual equivalent cost quite severely (up to one-third). On the other hand, part of the equipment and space was shared with adult endoscopy and not set up in a separate pediatric endoscopy unit. More general overhead costs such as the cost of training nurses and endoscopists, and overall hospital overhead costs were not included (only endoscopy-specific overhead costs were accounted for). 'Slack' time of labour was also not included (ie, nonproductive labour time) because it was assumed that any 'slack' time would be used productively for other tasks.

Clearly, taking into account 'unproductive' time would increase the salary component (physician, nurse and technician) per procedure. A realistic guess would be to increase the labour time by 20%.

Our detailed analysis from an activity-based approach of UGE offers a blueprint that can be replicated across different settings nationwide because it is well known that

endoscopy units vary widely in their staffing and utilization levels (17,18). This would be particularly useful in helping to define 'optimal' practices and to define guidelines for setting up endoscopy units. Our study also shows that the unit costs of UGE in Quebec are in line with published costs in Europe and that the average cost of a UGE might be expected to be in the range of CDN\$100 to CDN\$150 per procedure for an adult, mainly ambulatory, population (excluding laboratory and physician fees) in Quebec.

One must acknowledge that the physicians' reimbursement fees for performing the procedure and the nurses' salaries are generally lower than those in other provinces, where they are typically in the range of CDN\$100. On the whole, physician time is not to exceed 10 min to 15 min per procedure on average.

The importance of improving hospital accounting systems to better allocate overall hospital overhead costs to medical departments and units, and ultimately to individual procedures, should be stressed (19). We have shown that these overhead costs are an important component in the estimation of the overall total cost of the procedure. Full costing of medical procedures in itself is an important prerequisite for setting provincial reimbursement levels and hospital budget allocation, either from the perspective of the Ministry of Health or from that of the hospital administrator, although UGE represents only a relatively small part of the overall activities of a typical gastroenterology department.

More detailed costing analyses of routine medical procedures are needed to help optimize health care expenditures.

APPENDIX 1 Joint allocation within the gastroenterology department for upper gastrointestinal endoscopy (UGE)		
Cost item	Share (%)	Allocation key
Secretary	61.6	Proportion of total endoscopies that are UGE
Equipment use (light sources, etc)	61.6	Proportion of total endoscopies that are UGE
Pulse oxymeter	43.9	Proportion of total endoscopies that are UGE with sedation endoscopies
Endoscopy room use	61.6	
Cleaning room use	55.7	Proportion of the total number of endoscopes cleaned per day that are for UGE
Recovery room	18.9	Proportion of the total number of patients in the recovery room per day that are UGE patients

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