General Anesthesia

Declining randomized clinical trials from Canadian anesthesia departments?

[Déclin des études randomisées et contrôlées des départements d'anesthésie canadiens?]

Ban C.H. Tsui MD MSC FRCPC, Lisa X.Y. Li BSc, Victoria Ma, Alese M. Wagner BSc, Brendan T. Finucane MB CHB FRCPC

Purpose: The research productivity was estimated by publications from anesthesiology departments at Canadian universities over a five-year period, and the articles published were classified into several study designs.

Methods: In this observational study, the MEDLINE database was searched for publications listed by anesthesiology departments at Canadian universities as the primary corresponding source from 2000–2004. Abstracts were reviewed and each publication categorized into its respective methodological design. Impact factors of the journals in which the articles appeared were taken into consideration. "Total impact score" was defined as the total number of articles from a particular journal in a particular year multiplied by the impact factor value. Changes in overall publication numbers over the five-year period were compared and analyzed using Pearson correlation coefficients.

Results: Total Canadian anesthesia publications remained constant from 2000–2004. In this five-year time frame, the University of Toronto had the highest number of publications (271) followed by the University of Montreal (86), and McGill University (84). These universities conducted primarily randomized controlled trials (RCTs) whereas smaller Canadian universities mainly published case reports, reviews, and cohort studies. The number of RCTs conducted seems to be decreasing whereas the number of case reports and reviews being published are remaining constant over the five-year period.

Conclusion: Although overall numbers in anesthesia publications do not suggest a significant decline, the number of RCTs decreased during the years 2000–2004. The quality of anesthesia research appears to be comparable to those in other medical specialties, with larger institutions conducting RCTs and smaller institutions publishing more case reports.

***Objectif** : La productivité en recherche a été estimée par les articles provenant des départements d'anesthésiologie des universités canadiennes sur une période de cinq ans. Les articles ont été classifiés selon la méthodologie de l'étude.*

***Méthode** : Pour cette étude observationnelle, nous avons recherché dans MEDLINE les articles publiés par les départements d'anesthésiologie des universités canadiennes en tant que source primaire conforme entre 2000 et 2004. Les résumés ont été examinés et chaque article catégorisé selon sa méthodologie respective. Les facteurs d'impact des revues dans lesquelles les articles paraissaient ont été considérés. «Le score d'impact total» a été défini comme le total des articles d'une revue publiés au cours d'une année et multiplié par la valeur du facteur d'impact. Les variations du nombre total d'articles publiés sur cinq ans ont été comparées et analysées à l'aide des coefficients de corrélation de Pearson.*

***Résultats** : Le nombre total d'articles publiés sur l'anesthésie au Canada est demeuré constant entre 2000 et 2004. Pendant cette période, l'Université de Toronto a publié le plus d'articles (271) suivie de l'Université de Montréal (86) et de l'université McGill (84). Ces institutions ont surtout réalisé des études randomisées et contrôlées (ERC) tandis que les universités canadiennes plus*

From the Department of Anesthesiology and Pain Medicine, University of Alberta, Edmonton, Alberta, Canada.

Address correspondence to: Dr. Ban C.H. Tsui, Department of Anesthesiology and Pain Medicine, 8-120 Clinical Sciences Building, University of Alberta, Edmonton, Alberta, T6G 2G3, Canada. E-mail: btsui@ualberta.ca

Supported in Part by an Education and Research Fund, Department of Anesthesiology and Pain Medicine, University of Alberta Hospitals, Edmonton, Canada. Dr. Tsui is a recipient of the Clinical Investigatorship Award, Alberta Heritage Foundation for Medical Research, Alberta, Canada. Lisa Li is a recipient of the Canadian Institutes of Health Research Health Professional Student Research Award, Canada.

Assessed October 4, 2004.

Accepted for publication July 16, 2005.

Revision accepted August 25, 2005.

This article is accompanied by an editorial. Please see Can J Anesth 2006; 53: 217—21.

petites ont surtout publié des présentations de cas, des revues et des études de cohortes. Le nombre d'ERC semble diminuer alors que celui des présentations de cas et des revues demeure constant au cours de ces cinq ans.

***Conclusion** : Même si le nombre total d'articles publiés sur l'anesthésie ne montre pas de déclin significatif, le nombre d'ERC a diminué entre 2000 et 2004. La qualité de la recherche en anesthésie se compare à celle d'autres spécialités médicales, les plus grandes institutions menant les ERC et les plus petites publiant des présentations de cas.*

ANESTHESIOLOGY research not only improves our understanding of anesthesia and related fields of medicine, but it is also vital to the image of our specialty and is essential for our further development as a major medical discipline.[1] However, Orser *et al.* recently stated that compared to other medical specialties, anesthesiology has poor enrollment rates in research training programs.[2] Despite an increase in Canadian Institutes of Health Research funding opportunities, few Canadian anesthesiologists hold research grants from this agency. Clearly, opportunities for research are available, including those provided by the Research Grant, Fellowship and Career Scientist Award Programs of the Canadian Anesthesiologists' Society, and need to be seized.[2] A decline in the proportion of articles published by Canadian authors in anesthesia journals was reported between 1997 and 2001.[3] Speculation on the reasons for such decreases include rigorous regulations which act as a deterrent for researchers, and an emphasis on clinical care over research.[4]

Aside from sharing knowledge and new findings, publications increase an author's recognition within the medical community, and may also enable easier access to research funding resulting in future studies.[5] Productivity in a certain medical area is reflected by the number of articles published.[6] In this study, our objective was to estimate the research productivity of Canadian anesthesiology departments over a five-year period (January 2000 to December 2004, inclusive). To ensure consistency, we selected publications using Canadian anesthesiology departments in the corresponding address. We also aimed to classify the articles by publication type, and evaluated them using impact factors (IF) associated with the medical journals of interest.

Methods

An observational study examining the total number of anesthesia papers published over a time period of five years was performed. The total sum of published papers was obtained from the MEDLINE database using the PubMed search engine. MEDLINE field codes for address "[ad]", date published "[dp]", and publications type "[pt]" were combined with Boolean operators (AND, OR, NOT) to limit the search parameters. Variations of the keywords were included. The search parameter used was "anesthesia [ad] OR anaethesia [ad] OR anesthesiology [ad] OR anaesthesiology [ad] AND (Canada [ad] OR British Columbia [ad] OR BC [ad] OR Alberta [ad] OR Alta [ad] OR Saskatchewan [ad] OR Sask [ad] OR Manitoba [ad] OR Ontario [ad] OR Ont [ad] OR Quebec [ad] OR Que [ad] OR Newfoundland [ad] OR Nfld [ad] OR Nova Scotia [ad] OR NS [ad]) NOT letter [pt] NOT comment [pt]". In addition, limits were set under the phrase "publication date" to include journals from January 2000 to December 2004. The data was sorted using Reference Manager® (Reference manager v. 11, 2004, Thomson ISI ResearchSoft, Carlsbad, CA, USA). Manual separation was required only for those articles that included only the address of a hospital.

"Total impact score" was defined as the total number of articles from a particular journal in a particular year multiplied by the IF value. The IF for the resulting journals was obtained through the Institute for Scientific Information (ISI) Journal Citation Reports at the ISI Web of Knowledge website[7] and they define IF as the number of citations of a specific journal divided by the number of articles published by the journal in a two-year period. The total impact score values were calculated in order to take into account IF, and inclusion criteria required journal articles to be: 1) included in Medical Literature Analysis and Retrieval System Online (MEDLINE), 2) included in the Science Citation Index and 3) published by a Canadian university or affiliated hospital between January 2000 and December 2004. Any journals that were found in PubMed but not in the Science Citation Index were excluded from total impact score calculations.

Articles found to be published by Canadian universities between January 2000 and December 2004 were sorted by correspondence address into their respective universities and separated by year. When only a hospital was stated, the article was accredited to the affiliated university. Within each university, the number of articles for a certain journal in a particular year was counted. The abstracts of all results were manually reviewed, categorized into 14 methodological research designs (Table I) and counted. The research design categories included: animal studies, basic science research, case control studies, case reports, case series, clinical trials, cohort studies, meta-analysis, non-clinical studies (descriptive reports, historical arti-

TABLE I Definition of study designs[32]

Animal studies	Investigations using animals as surrogates or models for humans with the expectation that the results are pertinent to humans.
Basic science research	Studies that pursue knowledge about the most fundamental processes of life, such as how cells work.
Case control studies	A comparison of exposures of persons with disease with those persons without the disease.
Case report	A description of one or two cases, typically describing the manifestation, clinical course, and prognosis of that case.
Case series	A report of a number of cases of disease, describing the manifestation, clinical course, and prognosis of a condition. Usually five to 20 patients are included with no control group.
Clinical trial	An experiment to compare the effects of two or more interventions which was not controlled or randomized.
Cohort studies	An observation study in which a defined group of people (the cohort) is followed over time to determine the association between an exposure and an outcome.
Meta-analysis	The use of statistical techniques in a systematic review or overview to integrate and summarize the results of a collection of included studies.
Non-clinical	A study in which the intervention examined is not relevant in the clinical setting such as historical articles or studies investigating medical education.
Randomized controlled trial (RCT)	An experiment in which treatments, interventions, or enrollment into different study groups are assigned by random allocation rather than by conscious decisions of clinicians or patients.
RCT – Multicentre	RCTs that have been conducted in a multicentre setting.
Reviews	A summary of a number of different studies that may draw conclusions about a particular intervention.
Surveys	A study measuring the distribution of some characteristic in a population at a particular point in time.
Systematic review	A literature review focused on a single question which tries to identify, appraise, select and synthesize all high quality research evidence relevant to that question.

Adapted with permission from The Cochrane Collaboration.

cles, etc.), randomized controlled trials (RCTs), RCT – multicentre, reviews, surveys and systematic reviews. For those results without an abstract available, the full text article was assessed and the article was categorized according to the various methodological designs.

Statistical methods

Correlation statistical analysis to determine the Pearson correlation coefficient (r value)[8,9] was first conducted on the annual count of total published papers from each Canadian university to estimate changes over the 2000–2004 time period. Second, the r value was also calculated for various publication types for Canada as a whole over the five-year study period. The r value lies between -1.0 to +1.0 and a value of zero describes no association.[8,9] If the correlation coefficient is positive ($r > 0$), this means that the independent (e.g., time) and dependent variable (e.g., number of publications per centre) are positively correlated. In other words, as the independent variable increases, the dependent variable tends to increase. If the coefficient is negative ($r < 0$), the variables are negatively correlated; as the independent variable increases, the dependent variable tends to decrease.[9] A strong association is suggested as an absolute r value of 0.7 to 1.0;[8] however, this value is arbitrary and the extent of the association is only an approximation.

Results

Our search strategy generated 781 published articles; 771 (98.7%) of these anesthesia publications were authored by a member of a department of anesthesia in a Canadian university or its affiliated hospital. Linear regression showed that there was no decline in total published anesthesia papers but rather a slight increase (Figure 1). From 2000–2004 (Table II, Figure 2), the University of Toronto had the highest number of publications (271) followed by the University of Montreal (86), and McGill University (84). Only the University of Montreal demonstrated an increase in research productivity during this time (r = +0.95, Table III). Anesthesia publications from the top three universities accounted for 56.5% of the publications in Canada over the five-year period. When impact scores were evaluated, the rankings of the universities changed compared to the total number of papers published (ISI Journal), (Table IV). The University of Toronto had the highest impact score in each year and also the highest total score over the five-year period, being 569.6. McGill University increased to second place with a total score of 197.9, while the University of Montreal decreased to third with a total score of 164.4 (Table IV, Figure 3). Most anesthesia articles were published

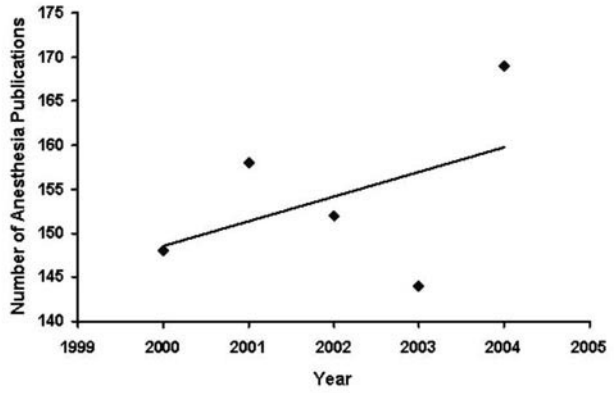

FIGURE 1 Linear regression on total number of anesthesia publications.

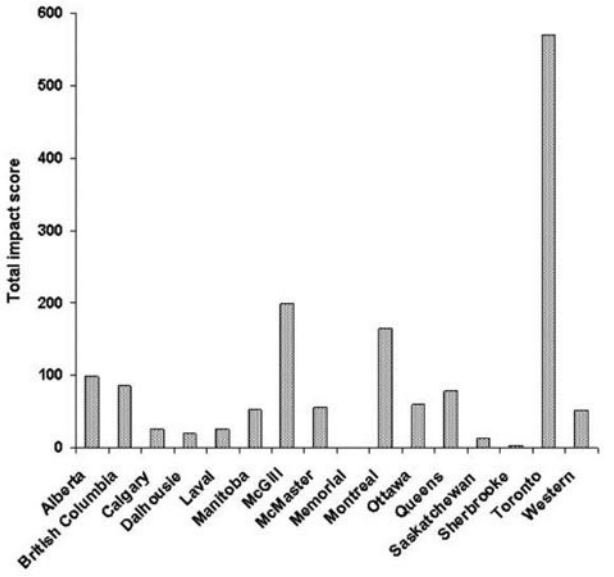

FIGURE 3 Total impact factor scores from each Canadian university from 2000–2004.

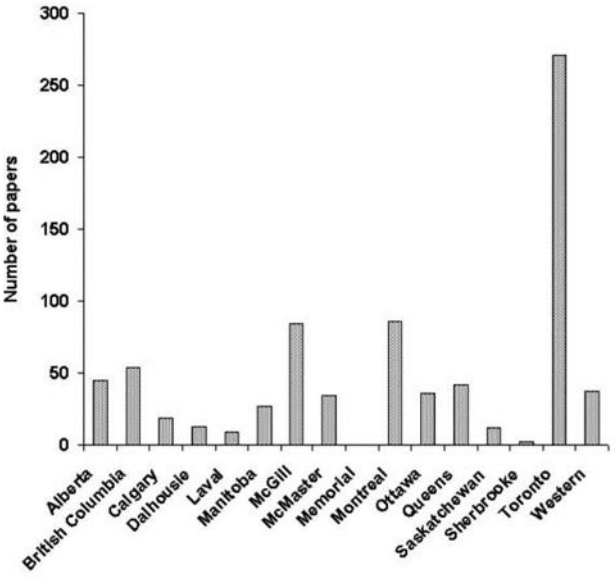

FIGURE 2 Total number of papers published by Canadian universities from 2000–2004.

in the *Canadian Journal of Anesthesia* (221 articles, 28% of total), followed by *Anesthesia and Analgesia* (113, 14%), and *Anesthesiology* (77, 10%).

In terms of total numbers of anesthesia papers published, the top three universities (University of Toronto, University of Montreal, and McGill University) are publishing mostly RCTs (17%, 24%, and 21% respectively – Table V). Over the five-year period, however, the number of RCTs conducted declined (r = -0.81), cohort studies increased (r = +0.85) and case reports (r = +0.16) and reviews (r = 0) remained constant (Table VI). Throughout Canada, RCTs were most frequently published (139, 18%), followed closely by case reports (138, 18%) and review papers (108, 14% – Figure 4). Large scale meta-analysis and systematic reviews ranked among the bottom of types of papers published (14, 2% and 9, 1% respectively). Smaller institutions such as the University of Manitoba, Dalhousie University, and Queen's University published almost an equal amount of case reports, cohort studies, surveys, animal studies, RCT, and non-clinical articles (Table V).

Discussion

General findings of current investigation

There appears to be a constant number of anesthesia publications each year in Canada with yearly fluctuations shown by a decrease over years 2000–2003 and an increase in 2004 (Figure 1). However, the number of RCTs conducted seems to be steadily decreasing (Figure 5) whereas the number of case reports and reviews being published remain constant (Table III). Only one out of 16 Canadian anesthesiology depart-

TABLE II Total number of anesthesia publications and total impact scores from 2000-2004

Canadian university	*Total number of papers*	*% of Canadian papers*	*Total # in ISI journals*	*Total impact scores*
Alberta	45	5.8	40	98.7
British Columbia	54	7	51	85.7
Calgary	19	2.4	16	26.0
Dalhousie	13	1.7	13	19.9
Laval	9	1.2	8	26.4
Manitoba	27	3.5	24	52.8
McGill	84	10.8	80	197.9
McMaster	34	4.4	32	56.2
Memorial	0	0	0	0
Montreal	86	11	83	164.4
Ottawa	36	4.6	29	59.7
Queen's	42	5.4	39	79.2
Saskatchewan	12	1.5	10	13.1
Sherbrooke	2	0.3	2	3.5
Toronto	271	34.7	256	569.6
Western	37	4.7	34	52.0

ISI = Institute for scientific information. Data arranged in alphabetical order according to university centre.

ments (University of Montreal) has clearly demonstrated a steady increase in publication numbers over the five-year period; this suggests that other Canadian universities are either stagnant in their research or as a recent report suggests,[3] anesthesia research productivity is on the decline. Low research productivity by Canadian anesthesia departments suggests an urgent need for Canadian anesthesiologists to consider the benefits of research and to encourage them to take advantage of the increase in research opportunities.

The top university based on total paper output was the University of Toronto (Table II, Figure 2); this institution has the largest Canadian anesthesia residency program in the number of teaching staff, hospital facilities and patient volume. Such resources offer an unequalled opportunity for University of Toronto anesthesia residents and staff in providing a supportive environment for learning and inquiry in all aspects of anesthesia. Although Toronto's publications did decrease slightly between 2002 and 2003, it remains the leader of Canadian anesthesia departments in terms of research productivity.

The University of Montreal had the second highest total number of papers published between the study period (Table II, Figure 2). This institution is also the only Canadian university that shows a consistent and steady increase ($r = +0.95$) in the number of anesthesia publications each year. Though 85% of residency programs have mandatory research requirements,[10] only the University of Montreal has a mandatory research rotation in their program; this rotation has been implemented for more than ten years.[A] Protocol preparation and submission is completed in the second year of the program, followed by a three- to four-month rotation in the third year during which the residents collect most of their data; data analysis

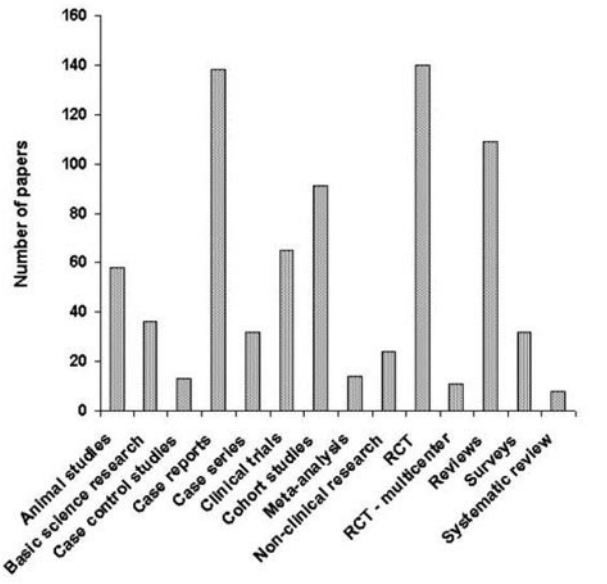

FIGURE 4 Types of anesthesia publications by Canadian universities from 2000–2004.

A *Girard F.* Program director, Department of Anesthesia, University of Montreal, Quebec, Canada [Personal Communication] 2004.

TABLE III Number of anesthesia publications each year from Canadian universities

Canadian university	*2000*	*2001*	*2002*	*2003*	*2004*	*Pearson correlation coefficient (r)**
Alberta	6	7	7	7	18	0.75
British Columbia	11	12	9	9	13	0.09
Calgary	5	2	5	3	4	--†
Dalhousie	5	2	2	1	3	--†
Laval	1	4	1	0	3	--†
Manitoba	7	3	6	7	4	-0.17
McGill	15	15	17	13	24	0.59
McMaster	6	6	7	9	6	0.36
Memorial	0	0	0	0	0	--†
Montreal	12	12	19	19	24	0.95
Ottawa	5	11	10	3	7	-0.19
Queen's	8	8	9	11	6	-0.09
Saskatchewan	3	3	3	1	2	--†
Sherbrooke	2	0	0	0	0	--†
Toronto	49	67	50	57	48	-0.24
Western	13	6	7	4	7	-0.66

*This value was calculated based on the number of publications over the five-year interval. †The *r* value was not calculated as numbers were too small to be an accurate representation. Data arranged in alphabetical order according to university centre.

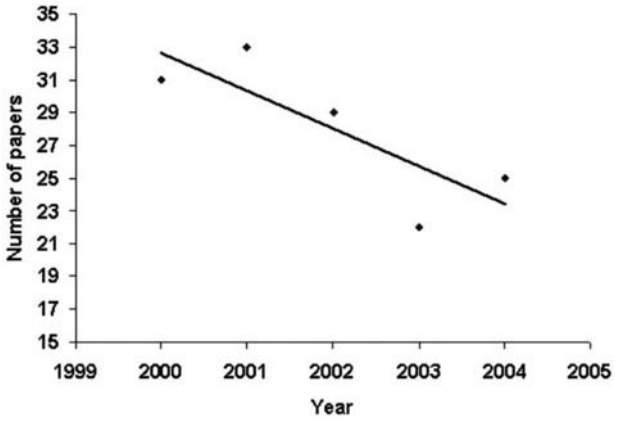

FIGURE 5 Linear regression on total number of randomized controlled trials conducted from 2000–2004 by Canadian universities.

and manuscript preparation is then completed concurrently or in the following year. More than 90% of the University of Montreal resident research is presented at anesthesiology meetings and is published in peer-reviewed journals. According to their program director, residents and supervising professors appreciate this research rotation. In fact, in a recent survey, most residents felt the biggest barrier to research was the lack of time.[10] It is likely that this structured research rotation has allowed more time for residents to pursue research and consequently, has lead to an increase in research productivity in this university department.

Types of anesthesia publications

Throughout the evaluated five-year period, the majority of published anesthesia manuscripts were RCTs and case reports. The numbers of RCTs decreased over this time frame (r = -0.81), cohort studies increased (r = +0.85) and the number of case reports remained relatively constant (r = +0.16 – Table VI). It is of considerable importance to examine the various methodological designs of anesthesia research for two reasons: firstly, the type of research conducted reflects upon the amount of time an individual study would require to bring a project to completion; this time includes developing study design or methodology, obtaining ethics approval, completing the study, and finally publishing in a peer-reviewed journal. Certain methodological designs inherently require more time and resources from inception to completion; for instance, a RCT generally requires more time for the researcher to complete than a report of a retrospective study employing a chart review. A second reason to examine the types of publication is to evaluate the quality of anesthesia research being conducted by Canadian universities. To illustrate, RCTs are considered to be of high quality design and provide greater evidence than other methodological designs.[11] On the other hand, case series and observational studies are

TABLE IV Ranking of Canadian universities based on total articles (ISI journals) and total impact score

	Total articles (ISI journals)	*Total impact score*
1	Toronto	Toronto
2	Montreal	McGill
3	McGill	Montreal
4	British Columbia	Alberta
5	Alberta	British Columbia
6	Queen's	Queen's
7	Western	Ottawa
8	McMaster	McMaster
9	Ottawa	Manitoba
10	Manitoba	Western
11	Calgary	Laval
12	Dalhousie	Calgary
13	Saskatchewan	Dalhousie
14	Laval	Saskatchewan
15	Sherbrooke	Sherbrooke
16	Memorial	Memorial

ISI = Institute for scientific information.

types of publications that rank lower in terms of quality of evidence, or in other words, are of "weaker" evidence.[11] However, these studies remain an important, valuable contributing factor towards improving anesthesia clinical practice.[12] Contrary to the general belief that anesthesia research is of low-quality in terms of strength of evidence, this study suggest that anesthesia research is comparable in quality to other medical specialties including surgery and internal medicine, where less than 10% of their published research are RCTs.[13,14] Further, a recent report also states that the quality scores for anesthesia research were neither better nor worse than the scores of other medical disciplines;[15] however, there is significant room for improvement in the quality of RCTs reported in leading anesthesiology journals. To definitively address this issue, further evaluation would be required to grade each paper on the basis of quality of study design and to assign appropriate levels of evidence.

It is evident that major university centres are conducting a larger proportion of large-scale clinical trials such as RCTs, whereas smaller institutions are publishing more case reports, cohort studies and reviews. This may be explained by the fact that larger institutions with a greater faculty size have increased human resources, as well as a much larger patient population for patient recruitment. Consequently, a larger working clinical environment appears to be more conducive to studies such as RCTs. On the other hand, institutions of a smaller size would require a lengthier study period in order to complete a RCT because there are fewer patients and fewer researchers conducting these studies. Results from a recent study evaluating Emergency Medicine programs at various centres from across the United States demonstrates similar findings.[16] In Henderson and Brestky's study, faculty size was taken into account and it was concluded that understandably, a larger faculty would be in a position to have higher academic output, since there would be an assumed greater diffusion of administrative and clinical burden.[16] This is essentially what is seen from our results, despite the fact that actual faculty member numbers were not reported.

The majority of anesthesia articles published in 2000–2004 were in anesthesia-specific journals such as the *Canadian Journal of Anesthesia* (28%), *Anesthesia and Analgesia* (14%), and *Anesthesiology* (10%). A similar study conducted in pediatric anesthesia gave similar results, showing that the majority of anesthesia articles were published in the three mentioned journals.[17] Journals for various medical disciplines were also publishing anesthesia research articles from our Canadian universities, ranging from basic science journals such as the *Journal of Physiology* and *Circulation*, to critical care medicine and surgery journals. It was important to include all types of journals, because all variations of anesthesia research were included in our search strategy, including animal studies, basic science investigations and human research.

Future direction of anesthesia research

With the continuing shortage of anesthesiologists in Canada and world-wide, the demands of clinical duties allow less time for research activities. It is the duty of each academic medical centre to provide the proper environment to facilitate education, clinical practice and research. Presently, it seems that our most difficult task is to convince anesthesia residents about the importance of research. Our current residents are the leaders of tomorrow and will eventually shape the practice of anesthesia. Thus, we need to find a viable solution to support more residents and faculty to engage in research. In an effort to encourage research in their centre, the Department of Anesthesia at the University of Toronto will be offering two Clinician Investigator Program[18] positions in 2005 for first year residents, and candidates in this stream will complete all rotations required by the Royal College for training in anesthesia. At approximately the end of their second postgraduate year, the residents will enroll in the Clinician Investigator Program at the University of Toronto and will concomitantly pursue a Master's or PhD degree in basic or clinical sciences. Although this Clinician Investigator Program will lengthen the residency by approximately one year,

TABLE V Top three types of publications from each Canadian university between 2000-2004

	Rank		
	1	*2*	*3*
Alberta	Case reports (36%)	Surveys (13%)	Cohort & non-clinical (9%)
British Columbia	RCTs (30%)	Case reports (19%)	Reviews (11%)
Calgary	Case reports (26%)	RCTs (21%)	Animal research & non-clinical (11%)
Dalhousie	RCTs & cohorts (23%)	Clinical trials & non-clinical (15%)	--*
Laval	Animal research (33%)	Case reports, Case series, cohorts, reviews (11%)	--*
Manitoba	Reviews (26%)	Animal research, cohorts & RCTs (15%)	--*
McGill	RCTs (21%)	Case reports (20%)	Reviews (13%)
McMaster	Animal research (18%)	Case reports (15%)	Reviews & meta-analysis (12%)
Montreal	RCTs (24%)	Cohorts & case reports (17%)	Clinical trials (14%)
Ottawa	RCTs (25%)	Case reports (22%)	Reviews (19%)
Queen's	Case reports (19%)	Cohorts & surveys (17%)	Animal research (14%)
Saskatchewan	Cohorts (33%)	Case reports, RCTs & reviews (17%)	--*
Toronto	RCTs (17%)	Reviews & case reports (15%)	Cohorts (11%)
Western	Reviews (32%)	Case reports (22%)	RCTs (16%)

RCTs = randomized controlled trials. *Percent too small to be an accurate representation. Data arranged by alphabetical order according to university centre.

it will result in dual certification for the resident as a specialist anesthesiologist and Clinician Investigator with the Royal College. This kind of innovative program is an important milestone in our specialty. It will be exciting to observe the progress of Toronto's Clinical Investigator Program; its impact on improving the research productivity of their centre may set an example for the country as a whole.

Limitations of current investigation

Clearly, one limitation to our study involves potentially under-reporting the total number of Canadian anesthesia publications for several reasons. First, we chose to search only MEDLINE because it is by far the most widely used medical information database in the world (1.3 million queries per day by 220,000 unique users).[19] MEDLINE includes approximately two-thirds of all major biomedical journals, but it does cover the major journals listed by the Science Citation Index under the subject heading 'anesthesiology.' Second, publications from institutions with productive research divisions who appear as second, third, or last authors on multi-departmental or multi-institutional studies may not have been accounted for, since our search examined only the affiliation of the first author. This limitation would be common to all Canadian universities in our search. A slight under representation of total anesthesia publications by these

TABLE VI Types of anesthesia publications published by Canadian universities from 2000-2004

*Publication type**	*2000*	*2001*	*2002*	*2003*	*2004*	*Pearson correlation coefficient (r)†*
Animal studies	13	9	5	10	21	0.45
Basic science research	7	9	10	8	2	-0.56
Case control studies	0	2	2	4	5	--‡
Case reports	28	28	27	22	33	0.16
Case series	5	4	6	4	13	0.67
Clinical trials	14	19	9	16	7	-0.54
Cohort studies	11	16	19	16	29	0.85
Meta-analysis	2	4	1	6	1	--‡
Non-clinical research	4	5	10	4	1	-0.34
RCT	31	33	29	22	25	-0.81
RCT – multicentre	3	3	1	3	1	--‡
Reviews	23	20	22	22	22	0
Surveys	5	5	10	4	8	0.31
Systematic reviews	2	1	1	3	1	--‡

RCT = randomized controlled trial. *For definitions of each study design, refer to Table I. †This value was calculated based on the number of publications over the five-year interval. ‡The *r* value was not calculated as numbers were too small to be an accurate representation. Data arranged in alphabetical order according to type of study.

limitations would have affected the overall results of our study regarding the ranking of individual institutions. Another possible deficiency of this study is that the rankings were based primarily on the total number of publications, and the size of each academic centre was not accounted for. However, we chose to omit this factor in our study because it is difficult to account for all anesthesiologists interested and actively participating in research at each centre and more error could have potentially been introduced by under or overestimating the size of each faculty. Thus, we decided to report the total number of anesthesia publications as an indication of research productivity.

In response to the increasing volume of information being published in a larger number of journals,[20] the IF was established in 1961 as an index of a journal's quality. However, the use of IF for measuring the quality of journals has been questioned. Opthof *et al.* suggests that IF does not reveal the quality of individual papers, but it can be used to compare the quality of journals.[21] Others remain doubtful as to the validity of IF when assessing the scientific merit of a journal.[22–25] Self-citation, author bias and counting methodology can inflate citation counts.[26–28] Despite the controversy,[23,24,28,29] IF is being used more frequently by institutions such as libraries. Consequently, the influence of IF is real, and must be accounted for.

A similar but more comprehensive study comparing Canadian research output between institutions for the period of 1994–1999 was published previously.[30] However, this study by Gagnon *et al.* differs not only in the study period, but also in the methodology used for counting the number of publications. The authors included all articles published on anesthetic and analgesic topics in major Canadian cities in their analysis; thus, their data may have included articles published by departments other than anesthesia in the same institution. Our study differed from that of *Gagnon et al.* as we have aimed to estimate the research output from each anesthesia department in all major Canadian universities, and we have included only those publications originating from all anesthesia departments across Canada between January 2000 and December 2004.

Conclusion and recommendations

Our study suggests that although Canadian anesthesia research did not decrease significantly between 2000–2004, the types of publication have gradually shifted to fewer reports of RCTs. The absence of a growing research enterprise within the specialty, and the type of research being reported remain issues that need to be addressed before we experience decreasing research productivity, as demonstrated in other countries including the United States and United Kingdom.[31] Silcox ***et al.*** reported that there is a lack of interest in research among Canadian anesthesia residents.[10] Creating a mandatory research rotation may encourage an increased focus on research, and would give residents ample time to gain knowledge of research methodologies and an appreciation of its importance. To encourage promising young residents to pursue academic careers in anesthesia, we must not only assist them scientifically and socially, but also provide them with sufficient research time in a proper environment. Each university should have enthusiastic faculty members to serve as preceptors in the discipline of research. This, in turn, will ensure

that we are creating and recruiting enthusiastic faculty members for the future.

References

1 *Nishino T.* Research in anesthesia and the future of our specialty (Editorial). J Anesth 2002; 16: 185–6.
2 *Orser BA, Miller DR.* New opportunities for anesthesia research in Canada (Editorial). Can J Anesth 2002; 49: 895–9.
3 *Figueredo E, Sanchez Perales G, Munoz Blanco F.* International publishing in anaesthesia - how do different countries contribute? Acta Anaesthesiol Scand 2003; 47: 378–82.
4 *Szokol JW, Murphy GS, Avram MJ, Nitsun M, Wynnychenko TM, Vender JS.* Declining proportion of publications by American authors in major anesthesiology journals. Anesth Analg 2003; 96: 513–7.
5 *Kumararatne M.* A piece of my mind. Why publish? JAMA 1997; 277: 957.
6 *Stossel TP, Stossel SC.* Declining American representation in leading clinical-research journals. N Engl J Med 1990; 322: 739–42.
7 Science Citation Index (SCI) Journal Citation Reports. A bibliometric analysis of science journals in the ISI database. Philadelphia: Institute for Scientific Information; 1998–2003.
8 *Myles PS, Gin T.* Regression and correlation. *In*: Myles PS, Gin T (Eds). Statistical Methods for Anaesthesia and Intensive Care. Oxford: Reed Educational and Professional Publishing Ltd.; 2000: 80.
9 *Rosner B.* Regression and correlation methods. *In*: Crockett C (Ed.). Fundamentals of Biostatistics, 5th ed. Pacific Grove, CA: Duxbury; 2000: 451–3.
10 *Silcox LC, Ashbury TL, Milne B, VanDenKerkhof EG.* Do anesthesiology residents want to be involved in research? Can J Anesth 2004; 51: A13 (abstract).
11 *Pandit JJ, Yentis SM.* All that glisters... how to assess the 'value' of a scientific paper. Anaesthesia 2005; 60: 373–83.
12 *Horlocker TT, Brown DR.* Evidence-based medicine: haute couture or the emperor's new clothes? (Editorial). Anesth Analg 2005; 100: 1807–10.
13 *Strippoli GF, Craig JC, Schena FP.* The number, quality, and coverage of randomized controlled trials in nephrology. J Am Soc Nephrol 2004; 15: 411–9.
14 *Brölmann HA, Kesteren PJ.* Levels of evidence in endoscopic research: a longitudinal survey. Gynecol Surg 2004; 1: 91–3.
15 *Greenfield ML, Rosenberg AL, O'Reilly M, Shanks AM, Sliwinski MJ, Nauss MD.* The quality of randomized controlled trials in major anesthesiology journals. Anesth Analg 2005; 100: 1759–64.
16 *Henderson SO, Brestky P.* Predictors of academic productivity in emergency medicine. Acad Emerg Med 2003; 10: 1009–11.
17 *Brambrink AM, Ehrler D, Dick WF.* Publications on paediatric anaesthesia: a quantitative analysis of publication activity and international recognition. Br J Anaesth 2000; 85: 556–62.
18 Royal College of Physicians and Surgeons of Canada Clinician Investigator Program. Clin Invest Med 1997; 20: 261.
19 *Lindberg DA.* National Library Of Medicine provides access for all. U.S. Medicine [serial online]; [cited 2005 Jun 27] 2003: 46. URL available from; http://www.usmedicine.com/column.cfm?columnID=120&issueID=46.
20 *Greene NM.* Anesthesiology journals, 1992. Anesth Analg 1992; 74: 116–20.
21 *Opthof T.* Sense and nonsense about the impact factor. Cardiovasc Res 1997; 33: 1–7.
22 *Hansson S.* Impact factor as a misleading tool in evaluation of medical journals (Letter). Lancet 1995; 346: 906.
23 *Rydholm A.* Impact factors (Editorial). Acta Orthop Scand 1998; 69: 221.
24 *Seglen PO.* Citation frequency and journal impact: valid indicators of scientific quality? (Editorial). J Intern Med 1991; 229: 109–11.
25 *Seglen PO.* Why the impact factor of journals should not be used for evaluating research. BMJ 1997; 314: 498–502.
26 *Campbell FM.* National bias: a comparison of citation practices by health professionals. Bull Med Libr Assoc 1990; 78: 376–82.
27 *Gallagher EJ, Barnaby DP.* Evidence of methodologic bias in the derivation of the Science Citation Index impact factor. Ann Emerg Med 1998; 31: 83–6.
28 *Gisvold SE.* Citation analysis and journal impact factors--is the tail wagging the dog? Acta Anaesthesiol Scand 1999; 43: 971–3.
29 *Zetterstrom R.* Impact factor and the future of Acta Paediatrica and other European medical journals. Acta Paediatr 1999; 88: 793–6.
30 *Gagnon RE, Macnab AJ, Blackstock D.* An inventory of Canadian anesthesiology. Human research from 1995 through 1999. Can J Anesth 2001; 48: 452–8.
31 *Rahman M, Sakamoto J, Fukui T.* Research output in anaesthesia: a quantitative ranking (Letter). Anaesthesia 2002; 57: 1213–4.
32 *Alderson P, Green S, Higgins J.* [Glossary of Terms in the Cochrane Collaboration.] Cochrane Handbook for Systematic Reviews of Interventions 4.2.4 [updated March 2003]. Available from URL; http://www.cochrane.org/resources/glossary.htm [accessed 2005 Jun 27].