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Influence of a Randomized Clinical Trial on Practice by Participating Investigators: Lessons From the Coronary Angioplasty Versus Excisional Atherectomy Trial (CAVEAT)

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Objectives. **We sought to determine whether the results of the first Coronary Angioplasty Versus Excisional Atherectomy Trial (CAVEAT-I) influenced subsequent practice patterns among the investigators.**

Background. **CAVEAT-I demonstrated that directional coronary atherectomy (DCA) resulted in higher rates of early complications at a higher cost and with no clinical benefit. We sought to determine whether these results influenced subsequent use of procedures among CAVEAT-I investigators.**

Methods. **We compared the results of a week-long registry of all coronary interventions performed at 35 CAVEAT-I sites in 1994 with those of a similar registry obtained in 1992 before the trial, the results of which were published in 1993. For control purposes, the use of procedures was studied at 24 additional sites to provide insight into practice at hospitals not participating in the trial. A total of 1,465 interventions were analyzed.**

Results. **Ninety-four percent of CAVEAT-I sites responded. Utilization rates differed between CAVEAT-I and CAVEAT-I follow-up ($p < 0.001$). Balloon angioplasty decreased from 83.8% to 68.5%, DCA increased slightly from 10.7% to 14.1%, and the use of other devices increased from 5.4% to 17.5%. Stand-alone balloon use was more prevalent at nonparticipating control sites than at sites that took part in CAVEAT-I ($p < 0.001$).**

Conclusions. **Paradoxically, despite the negative findings of CAVEAT-I, there was a noteworthy trend toward an increase in the use of DCA and other devices at CAVEAT-I sites. Our findings suggest that among investigators in the trial, there may have been a lack of influence of trial data on clinical practice patterns 1 year after publication of the results. Ethics of protocol: Both CAVEAT I and II were approved by the Institutional Review Board at each study site.**

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Percutaneous transluminal coronary balloon angioplasty (PTCA), first performed in 1977 by Gruentzig et al. (1), gained acceptance and entered routine clinical practice without a controlled clinical trial (2). Clinical experience and carefully collated, multicenter observational data soon identified its limitations, including a 3% to 5% incidence of abrupt closure (resulting in myocardial infarction, emergency coronary artery bypass graft surgery or death) and a 30% to 50% incidence of restenosis (3).

Seeking to improve on the results of stand-alone balloon angioplasty, aggressive investigation of newer devices began in the mid-1980s (4). These devices included directional, rotational and extractional atherectomy, laser angioplasty and stents. Based on the attractive notion that plaque removal rather than compression was the preferred strategy, Simpson introduced directional atherectomy in 1984. Directional coronary atherectomy (DCA) was approved in October 1990 by the Food and Drug Administration (FDA) on the basis of data from a multicenter observational registry of 838 consecutive patients (2,5).

CAVEAT-I tested the hypothesis that DCA was superior to PTCA for treating native primary coronary lesions amenable to either intervention (6). This was the first large-scale, randomized trial of a new device in cardiovascular medicine.

A total of 1,012 patients were randomized at 35 investigational sites in North America and Europe. Over 70% of all

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Abbreviations and Acronyms

CAVEAT = Coronary Angioplasty Versus Excisional Atherectomy Trial
DCA = directional coronary atherectomy
FDA = Food and Drug Administration
PTCA = percutaneous transluminal coronary angioplasty

eligible patients and 30% of all atherectomy procedures performed at the study sites were randomized into the study (see Appendix for inclusion/exclusion criteria). The trial demonstrated that DCA resulted in higher rates of early complications at a higher cost and with no clinical benefit. The study results were initially presented at the American Heart Association meeting in November 1992 (7), followed by full publication in the *New England Journal of Medicine* in July 1993 (6).

The purpose of the current study was to establish whether the results of CAVEAT-I influenced subsequent practice patterns among investigators in the trial. Because of the negative results of atherectomy, we hypothesized that physicians in the trial would use PTCA more often than DCA after learning the results of the trial that they had participated in.

Methods

Surveys. In 1992, before CAVEAT-I, a 1-week long registry of all coronary interventions performed at 35 CAVEAT-I sites was collated by questionnaires sent by mail to site coordinators. The questionnaire sought to establish angina history, coronary anatomy and specific coronary procedures in the baseline study group. After publication of the trial results in July 1993, we compared the results of a slightly simplified follow-up survey performed from April 18 to 22, 1994 (Fig. 1) with those results obtained in 1992.

For control purposes, the use of procedures was studied at 24 additional sites to provide insight into practices at hospitals not participating in the trial. These sites had randomized patients in CAVEAT-II (8) (comparing DCA and PTCA in vein grafts), and therefore had a readily available mechanism for data collection.

Study Site_____
Patient Initials: _____
Date of Birth: _____
Date of Procedure: _____
Sex: Male Female

GENERAL INFORMATION

Is the intervention part of an ongoing randomized study of angioplasty or atherectomy?
Yes No

Reason for Revascularization (check one only)
Asymptomatic with positive functional study
Stable angina
Unstable angina - If yes, check all that apply
Rest pain
Post infarct (< 14 days) ischemia
Accelerating pattern
Pain with ECG changes

Pain only with MI: Yes No
Previous MI: Yes No
Previous percutaneous intervention: Yes No
Diseased vessels (> 50%):
0 1 2 3

INTERVENTION: ANATOMY AND PROCEDURE

Place the native coronary artery or graft site that received an intervention next to the procedure it received:

_____Standard balloon angioplasty
_____Long Balloon (3 and 4 cm) angioplasty
_____Perfusion Balloon angioplasty
_____Laser or Laser Balloon
_____Stent
_____Rotablator
_____Directional coronary atherectomy
_____Extraction atherectomy (TEC)
_____Other

Figure 1. Sample of survey questionnaire.

Table 1. Definition and Classification of Interventions

Intervention	Classification	Frequency (no. of pts)		
		CAVEAT-I		CAVEAT-II (control)
		Baseline	Follow-Up	
Balloon only	Balloon	539	443	307
DCA only	DCA	42	57	23
Other intervention only	Other	35	62	22
DCA and other	DCA	—	3	—
Balloon and other	Other	—	51	25
Balloon and DCA	DCA	27	28	14
Balloon, DCA and other	DCA	—	3	2
Total		643	647	393

CAVEAT = Coronary Angioplasty Versus Excisional Atherectomy Trial; DCA = directional coronary atherectomy; pts = patients.

Definitions. For the purposes of this study, three categories of interventional therapy were identified. "Balloon" was defined as stand-alone standard balloon, long balloon or perfusion balloon angioplasty, or a combination. "Atherectomy" was defined as any coronary intervention inclusive of stand-alone DCA. "Other devices" was defined as any intervention (single or combined) other than stand-alone balloon angioplasty or atherectomy as previously defined (Table 1).

Statistics. Descriptive statistics were calculated for clinical characteristics, procedural indications, coronary anatomy, specific intervention and investigational sites of the study group during both surveys. Post-trial follow-up data from the CAVEAT-I sites, CAVEAT-II (control) sites and the combination of both groups of sites were compared with one another and with pretrial CAVEAT-I data using the chi-square test. Ninety-five percent confidence intervals were calculated for each type of intervention. Pretrial and post-trial interventions were also compared by location of investigational site (United States, Europe or Canada) using the chi-square test.

Six factors were assessed to identify independent predictors of type of intervention. These factors were gender, reason for revascularization, previous percutaneous intervention, vessel type (native vs. vein graft), site of intervention (United States vs. other country) and anatomy (left anterior descending vs. other coronary artery). First, chi-square analysis was used to identify univariate predictors of intervention type. Next, factors that were univariately significant at $p < 0.15$ were considered in a stepwise logistic regression model. A factor entered the model at $p < 0.15$ and remained in the model at $p < 0.05$. Two models were evaluated: one with DCA as the outcome versus the other two interventions (balloon angioplasty/other devices), and the other with balloon angioplasty as the outcome versus the other two interventions (DCA/other devices).

Results

Survey response. Baseline pretrial 1992 CAVEAT-I universe survey data were obtained from 643 patients at 34 CAVEAT-I sites. The site response rate was 97% (34 of 35 sites). Composite data for the present study were obtained from 1,040 patients undergoing 1,465 interventions at 57 CAVEAT sites. Of these patients, 647 underwent an intervention at sites that had partaken in CAVEAT-I, whereas 393 did so at "control" sites that had not participated. The post-trial survey response rate was 94.3% of sites (33 of 35) that took part in CAVEAT-I, but 97% (33 of 34) of those CAVEAT-I sites that participated in the baseline survey. The only CAVEAT-I site that did not collate pretrial survey data at baseline did not participate in this follow-up. Among CAVEAT-II post-trial "control" sites, the response rate was 100% among the 19 new centers that randomized patients in CAVEAT-II. Along with those sites that had taken part in CAVEAT-I, a total of 54 sites randomized patients in CAVEAT-II. While the original CAVEAT-I pretrial baseline data base consisted only of sites in the United States and Europe, a number of Canadian sites enrolled patients in CAVEAT-II.

Descriptive statistics. Patients who underwent interventions during the study period ranged in age from 19 to 93 years (mean 63 ± 11.4). Two-thirds were men (69.1%), and the most common indication for intervention was unstable angina (74%). Only 3.5% of interventions were part of an ongoing randomized study, indicating that the choice of interventional strategy was almost universally driven by physician preference. Thirty-six percent (36.2%) of patients had a previous myocardial infarction, whereas 33.6% had undergone a previous percutaneous intervention. Most interventions (86.5%) were performed on native coronary lesions, and most patients had single- (45.8%) or double-vessel (32.4%) disease. Based on characteristics for which comparative data are available, the target group was broadly similar to the baseline group. One or two interventional devices were used in 93.1% of patients (mean 1.4 ± 0.7 devices).

All major comparisons of post-trial CAVEAT-I, CAVEAT-II (control sites) and the combined post-trial survey data set with the CAVEAT-I pretrial baseline universe were statistically significant ($p < 0.001$) (Table 2). At CAVEAT-I sites, the percentage of patients undergoing stand-alone balloon angioplasty decreased significantly (83.8% to 68.5%) since CAVEAT-I; the percentage treated with DCA remained stable (10.7% to 14.1%); and the percentage of those undergoing other device interventions increased significantly (5.4% to 17.5%). A comparison of post-trial CAVEAT-II (control) data with pretrial CAVEAT-I data also revealed differences in use of stand-alone balloon angioplasty, DCA and other devices in 1994 compared with patterns in 1993 ($p < 0.001$). Interestingly, post-trial stand-alone balloon use was more prevalent at CAVEAT-II (community control) sites than at sites that originally took part in CAVEAT-I (78.1% vs. 68.5%, $p < 0.001$), suggesting a gradient of device use from sites that had participated in CAVEAT-I to control sites that had not.

Analysis. Analysis of interventions by study site location (United States, Europe and Canada) revealed that interval changes in utilization of devices was most evident among U.S.

Table 2. Frequency of Interventions at Follow-Up Compared With Original CAVEAT-I Data

	CAVEAT-I			
Intervention	Baseline (n = 643)	Follow-Up (n = 647)	CAVEAT-II (control: n = 393)	Combined Data* (n = 1,040)
Balloon				
No. (%) of pts	539 (83.8%)	443 (68.5%)	307 (78.1%)	750 (72.1%)
95% CI	80.9–86.7	64.9–72.1	74.0–82.2	69.4–74.8
DCA				
No. (%) of pts	69 (10.7%)	91 (14.1%)	39 (9.9%)	130 (12.5%)
95% CI	8.3–13.1	11.4–16.8	6.9–12.9	10.5–14.5
Other				
No. (%) of pts	35 (5.4%)	113 (17.5%)	47 (12.0%)	160 (15.4%)
95% CI	3.6–7.2	14.6–20.4	8.8–15.2	13.2–17.6
Vs. CAVEAT-I		$p < 0.001$	$p < 0.001$	$p < 0.001$

*CAVEAT-I follow-up group plus CAVEAT-II control group. CI = confidence interval; other abbreviations as in Table 1.

investigators ($p < 0.0001$) (Tables 3 and 4). Interval differences in utilization in the small sample of international sites were of marginal statistical significance ($p = 0.047$). These estimates may, however, be unstable. Directional atherectomy, for example, went from a 0.0% to 12.0% rate of use among the European sites after CAVEAT-I. In comparison with Europe and Canada, there does seem to be relatively greater overall use of devices at U.S. CAVEAT sites. However, the sparse number of CAVEAT sites in Europe and Canada dictates caution in generalizing this observation.

In the regression model, factors found to be independently predictive of use of DCA were gender (more often in men than in women), U.S.-based investigational site and lesion location in the left anterior descending coronary artery (Table 5). Vessel type (more often in native than in vein grafts) may also have been predictive. Although a trend in favor of use in the proximal segment of the left anterior descending coronary artery was evident, DCA was frequently used in other anatomic segments and vessel sites. Approximately 40% of overall DCA use was either in the right or left circumflex vessels.

Discussion

In the current study, we sought to establish whether the findings of CAVEAT-I, published in a major peer-reviewed journal (6), modulated the practice of DCA among physician-investigators who designed the trial, participated in it and subsequently co-authored publication of its results.

Summary of findings. CAVEAT-I found that patients randomized to DCA had higher angiographic gain. However, there were more acute complications and greater costs were incurred, with no apparent clinical benefit at 6 months (6). Furthermore, at 12 months there was a persistent excess of cumulative deaths and the composite of death and nonfatal myocardial infarction in the group randomized to DCA (9).

In follow-up, we found that there had been a significant decline in the proportion of procedures relying exclusively on balloon angioplasty and paradoxically, despite the negative results of CAVEAT-I, a noteworthy trend toward an increase in the use of DCA and other devices at CAVEAT sites. These results suggest that among investigators in the trial, there may have been a lack of influence of CAVEAT-I data on clinical

Table 3. Comparison of Frequency of Interventions by Study Site Location

	CAVEAT-I						
	Baseline [no. (%) of pts]		Follow-Up [no. (%) of pts]		CAVEAT-II (control) [no. (%) of pts]		
Intervention	U.S.	Europe	U.S.	Europe	U.S.	Europe	Canada
Balloon	508 (83.3%)	31 (93.9%)	406 (68.0%)	37 (74.0%)	212 (73.1%)	18 (81.8%)	77 (95.1%)
DCA	69 (11.3%)	0 (0.0%)	85 (14.2%)	6 (12.0%)	36 (12.4%)	2 (9.1%)	1 (1.2%)
Other	33 (5.4%)	2 (6.1%)	106 (17.8%)	7 (14.0%)	42 (14.5%)	2 (9.1%)	3 (3.7%)
Total	610	33	597	50	290	81	22

U.S. = United States; other abbreviations as in Table 1.

practice patterns in 1994—a full year after publication of the results.

Why did CAVEAT have no apparent effect on investigator practice? Acceptance of trial results is probably influenced by pretrial probability, based on perceptions of treatment efficacy. If pretrial views about a device are extremely positive or negative, results in a direction opposite to the baseline assumption are less likely to make an impact. Additional trials may then be needed to produce a real change in physician practice and to resolve the tension between policy and culture. Likewise, if pretrial views were of intermediate certainty, a well formulated trial might be expected to provide "definitive" assurance. Curiously, the results of the Canadian atherectomy trial were published in the same issue of the *New England Journal of Medicine* (10). The simultaneous appearance of two negative trials might have been expected to edify the conclusions of each one.

CAVEAT-I was performed in the early years of the new device era, characterized by a momentum of novelty and preoccupation with lumen debulking (11). The new device allure may have contributed to a general expectation that atherectomy would prevail. Because the directionality of the results was at odds with data from premarket approval observational registries (2), the degree to which DCA in CAVEAT-I simulated application in the "real-world" became a theme for counter-marketing.

Like other debulking technologies, DCA has the potential to achieve better angiographic outcomes with significant immediate gratification to the operator. Looking back, many investigators thought the performance of DCA in CAVEAT was not aggressive enough. Curiously, however, most did believe at the time of the study that they had performed "aggressive" atherectomy. Discrepancies only became apparent when subjective site assessments were compared with objective core-laboratory measurements using worst projection analysis. The level of safety at which a "bigger" lumen obtained by cutting becomes "better" for the patient remains an unanswered question. However, there is a dissociation between clinical and angiographic end points, a phenomenon that has only recently begun to be appreciated (12).

A commonly cited issue in explaining the lack of impact of clinical trials relates to the similarity between the "study" and "practice" groups. To address this issue, we performed an exploratory analysis comparing clinical and gross anatomic characteristics of patients in the trial with those of patients at all sites surveyed for the purpose of this analysis (Table 6). Among variables common to both data sets, we found minor but statistically significant differences in the proportion of patients undergoing an intervention who had a history of myocardial infarction or unstable angina. Although these observations are interesting, it is important to keep in mind that statistical significance does not necessarily translate into clinical significance. The randomized study group also included a greater frequency of patients with single-vessel disease—an observation that has also been made in the major thrombolytic trials. More extensive disease in the 1994 practice group might have been expected to result in even greater caution in the use of DCA.

However, the desire of competing physicians, medical centers and the medical industry to offer the "newest, brightest and most sophisticated" technologies in practice (13) may have sustained a positive feedback loop of referrals. The observed gradient of post-trial device use between CAVEAT-I follow-up and CAVEAT-II (control) sites might have been due to this phenomenon.

The issue of when clinical trials should be conducted during

Table 4. Statistical Comparisons of Frequency of Interventions by Study Site Location

Site	p Value
American	
Ia, Fa, IIa	< 0.0001
Ia vs. Fa	< 0.0001
Ia vs. IIa	< 0.0001
Fa vs. IIa	0.29
European	
Ie, Fe, IIe	0.20
Ie vs. Fe	0.047
Ie vs. IIe	0.18
Fe vs. IIe	0.77
CAVEAT-I	
Ia vs. Ie	0.11
CAVEAT-I follow-up	
Fa vs. Fe	0.68
CAVEAT-II control	
IIa, IIe, IIc	0.0011
IIa vs. IIe	0.66
IIa vs. IIc	< 0.0001
IIe vs. IIc	0.08

I = CAVEAT-I; II = CAVEAT-II; a = United States; c = Canada; e = Europe; F = follow-up; other abbreviations as in Table 1.

Table 5. Stepwise Logistic Regression Analysis*

Intervention and Independent Factors	p Value	OR (95% CI)
DCA (n = 959) (model includes vessel type)		
Gender (M/F)	0.029	1.65 (1.05–2.58)
Vessel type (native/SVG)	0.054	2.02 (0.99–4.13)
Study site (U.S./C or E)	0.007	4.15 (1.49–11.63)
LAD (Y/N)	< 0.001	2.39 (1.62–3.54)
DCA (n = 959) (model excludes vessel type)		
Gender (M/F)	0.034	1.62 (1.04–2.54)
Study site (U.S./C or E)	0.008	3.98 (1.43–11.11)
LAD (Y/N)	< 0.001	2.50 (1.69–3.69)
Balloon (n = 980)		
Vessel type (native/SVG)	0.004	1.77 (1.19–2.62)
Study site (U.S./C or E)	< 0.001	3.83 (1.96–7.50)
LAD (Y/N)	0.005	1.52 (1.14–2.02)

*Analysis includes patients with complete data only. C or E = Canada or Europe; F = female; LAD = left anterior descending coronary artery; M = male; N = no; OR = odds ratio; SVG = saphenous vein graft; Y = yes; other abbreviations as in Tables 1 to 3.

Table 6. Comparison of Clinical and Anatomic Characteristics of CAVEAT-I Group With Post-Trial Survey Registry Group

Variable	CAVEAT-I Group [no. (%) of pts]	Entire Follow-Up Survey Group* [no. (%) of pts]	p Value
Gender			
Male	734 (72.5%)	690 (69.1%)	0.09
Female	278 (27.5%)	309 (30.9%)	
History of MI			
Yes	430 (42.5%)	346 (36.2%)	0.004
No	582 (57.5%)	610 (63.8%)	
Unstable angina			
Yes	688 (68.0%)	710 (74.0%)	0.003
No	324 (32.0%)	249 (26.0%)	
No. of diseased vessels			
1	663 (65.5%)	431 (45.8%)	< 0.001
2	293 (29.0%)	305 (32.4%)	
3	56 (5.5%)	206 (21.9%)	
If unstable angina			
Pain at rest			
Yes	309 (44.9%)	175 (25.5%)	< 0.001
No	379 (55.1%)	511 (74.5%)	
Pain with ECG changes			
Yes	134 (19.5%)	127 (18.5%)	0.65
No	554 (80.5%)	559 (81.5%)	
Angina after MI			
Yes	117 (17.0%)	80 (11.7%)	0.005
No	571 (83.0%)	606 (88.3%)	
Accelerating pattern			
Yes	426 (61.9%)	342 (49.9%)	< 0.001
No	262 (38.1%)	344 (50.2%)	

*Only complete data used. ECG = electrocardiographic; MI = myocardial infarction; other abbreviations as in Table 1.

the life cycle of a new device is a generic one common to all device investigations (2). After the CAVEAT-I trial was initiated, newer product lines with improved handling characteristics, such as newer generation SCA-EX devices and the Atherocath-GTO, were released. Whether these devices, if available earlier, would have affected the results of CAVEAT is unknown.

In a post hoc CAVEAT-I subgroup analysis, clinical site remained a statistically significant predictor of acute gain after adjustment for device size, lesion location, vessel diameter and diabetes (14). Bearing in mind the statistical limitation of such analyses, this raises the possibility that the composite multicenter result did not reflect uniformly optimal device use. Indeed, many investigators pointed to other investigators and sites as being responsible for the negative results of the trial! In the Balloon Versus Optimal Atherectomy Trial (BOAT) (15), which began on May 9, 1994, only one "certified" investigator per site was allowed. It is not clear that this is the solution to the dilemma.

In part owing to the embryonic state of the field, there was early controversy over the thresholds for significant creatine kinase release in the setting of interventional procedures and "composite" outcome measures, which combined death, myocardial infarction and target vessel revascularization. Some physicians thought postintervention myocardial infarctions were meaningless. Some of these issues have since become better understood (16).

The paradoxic increase in DCA and other device use was particularly evident in U.S. sites. Other recent international studies have also found international differences in technology intensity (17). Furthermore, corporate sales data revealed a devices for vascular intervention worldwide sales plateau in 1994 at $80 million, although domestic (United States) sales *increased* by 10% to 11% (18). Directional atherectomy comprised 14% of interventions in the United States but only <3% in Europe. It is conceivable that investment of professional careers in new coronary devices by U.S.-based investigators played a role in making acceptance of CAVEAT-I results difficult.

Other factors may also have played a role. Directional atherectomy specimens were required for bench research purposes in at least one site. Directional atherectomy has continued to be reimbursed without limitations or conditions by third-party payors, and access to resources has been relatively unlimited at the study sites participating in this survey. The FDA made no changes in approved indications for the technique despite the findings of CAVEAT-I. However, the FDA approved, or was in the process of approving, other new devices during the same time frame as the CAVEAT studies. These parallel events may have fueled the momentum for new device use in multiple permutations and combinations.

In summary, the following factors may have played a role in the lack of influence of CAVEAT's data: positive pretrial views on atherectomy; the allure of a new device that had the potential to achieve better angiographic results; the desire of competing physicians and hospitals to have and use the newest technology; and the possibility that the composite results did not reflect uniformly optimal device use.

Comparison with other clinical trials. To our knowledge, our study is the first to specifically investigate the impact of a trial on the practice of investigators. Previous published data suggest that clinical trials can lead to changes in practice in the community, although usually after a period of lag (19,20). More recently, Lamas et al. (21) concluded that well executed clinically relevant trials published in highly visible journals had an early measurable impact on clinical use of aspirin and calcium antagonists. The Gruppo Italiano per lo Studio della Streptochinasi nell'Infarto Miocardico (GISSI) trials suggested that a culture of integration of clinical trial methodology into routine practice helped subsequent acceptance of results (22). In a separate study, the level of use of thrombolytic agents in a region of England mirrored previous participation in multicenter trials of thrombolysis (23,24). In none of these situations, however, were operator-investigators themselves on trial—a factor presumably peculiar to new device investigation.

How the researchers and sponsors of trials interact with one another and with the rest of the health care community is a key factor in determining impact (25). In the United States, the National Registry of Myocardial Infarction exemplifies a mechanism for educating physicians and hospitals on the

clinical use of thrombolytic therapy after the major thrombolytic trials.

Study limitations. Our follow-up survey was designed to last 1 week, primarily because the baseline survey was obtained over a 1-week period. It is conceivable that either sample was unrepresentative of the range of practice over a longer period of time. There were too few study sites in Canada and Europe to make generalizations about practice in those countries. However, 1994 worldwide interventional cardiology financial data reveal market proportions of next-generation devices and balloon angioplasty that are consistent with our observations in the CAVEAT follow-up data base (18).

For reasons of cost and compliance, we did not document detailed comparative information on lesion morphology and vessel size. It is conceivable that evolution of referral patterns over time might have led to a peculiar aggregation of new device–requiring lesions at CAVEAT sites.

Last, and perhaps most important, an alternative explanation of our results could be that the trial blunted what might otherwise have been a steep rise in the use of atherectomy had the results been more positive. Indeed, the observation that 14% of U.S. sites in 1994 used DCA was at odds with expected corporate sales projected at 25% (18).

Study implications. Our study supports the need to better understand the dynamics of acceptance of study data after randomized, controlled trials of medical devices, particularly among operator-investigators (26,27). A lack of enthusiastic dissemination of trial results and implications to noninvestigator practitioners and policymakers by researchers and study sponsors could limit rapid translation of study results to practice (28). Merely publishing the results of a well designed study in an influential journal is not enough to effect a rapid change in practice pattern, as was suggested in a previous report (21).

Incorporation of randomized, controlled data into practice guidelines, quality improvement programs and medical necessity assessments by third-party payors might help facilitate evidence-based practice in an era when informed judgments must be made in the setting of declining resources. However, implementation of trial results needs to be balanced against the tide of rapidly evolving technology and the uncertainties that go along with it. Clinical trial design may need to be critically reevaluated to address this problem (29).

Research and development of a combined AtheroCath-Ultrasound catheter, may lead to safer, lesion-specific and more truly directional atherectomy procedures. Lesion-specific trials may emerge as a clinical trial strategy in the future (30). With the passage of time since CAVEAT, however, it would appear that the focus has shifted away from balloon angioplasty as a point of reference. Directional atherectomy must now demonstrate superiority over stents (31,32).

Conclusions. After CAVEAT-I, there was a significant decline in the proportion of interventions relying exclusively on balloon angioplasty, and paradoxically, despite its negative findings, a noteworthy trend toward an increase in the use of DCA and other devices at CAVEAT-I sites. Our findings suggest that among investigators in the trial, there may have been a lack of influence of CAVEAT-I data on clinical practice patterns in 1994, 1 year after full publication and 2 years after the results were known. However, we acknowledge that the pattern of DCA use in our survey may have been transient, as there has subsequently been a decline in 1995 to 1996 due to the emergence of stents as an approved interventional device.

Appendix

Inclusion and Exclusion Criteria: CAVEAT I and II

CAVEAT I

Inclusion Criteria

1. Patients who had ischemic heart disease deemed suitable for either atherectomy or angioplasty who were willing to give written informed consent.
2. Presence of diseased native coronary vessels that had not undergone a previous coronary intervention, that had stenosis of at least 60% on visual assessment and a lesion length of ≤12 mm and that were suitable for either a ≥6F cutter or a ≥3.0-mm balloon.
3. Patients with multivessel coronary disease were eligible, but a single vessel was specified as the target before coronary intervention began.
4. All lesions had to be amenable to both techniques.

CAVEAT II

Inclusion Criteria

1. Patients with primary vein graft lesions suitable for >6F atherectomy catheter (>3.0 mm); a subtotal diameter stenosis >60% and <100% by visual assessment; and lesion length <12 mm.
2. If more than one lesion was present in the vein graft, all had to be amenable to either technique.

Exclusion Criteria

1. Patients who had a myocardial infarction in the previous 5 days.
2. Participation in another study.
3. Restenotic lesion.
4. Investigator preference not to randomize.

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