Racial differences in the incidence of femoral bypass and abdominal aortic aneurysmectomy in Massachusetts: Relationship to cardiovascular risk factors

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Purpose: Atherosclerotic disease appears to be more severe in black patients than in white patients, but abdominal aortic aneurysms, which have traditionally been believed to have an atherosclerotic cause, are reported to be less common in black patients than in white patients. Our goals were to compare and contrast factors associated with the development of abdominal aortic aneurysms and clinically significant atherosclerotic occlusive disease (1) to determine whether these diseases share a common cause and (2) to explore their association with race.

Methods: Dual case-control studies were conducted with multivariate analysis to compare cases (patients undergoing aneurysmectomy or patients undergoing femoral bypass) with a comparison group consisting of patients who had undergone appendectomy. Two data sources were used: (1) hospital discharge data for Massachusetts from 1984 through 1988 and (2) medical records at University Hospital of Boston and Boston City Hospital. For both the Massachusetts database and the hospital chart review, records were obtained for all patients discharged between January 1984 and December 1988 with an International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) procedure code for abdominal aortic aneurysm resection (38.44) or aneurysmorrhaphy (38.34) or with a procedure code for femoral artery bypass/reconstruction (39.29). To conduct a nested case-control study, records were also obtained for a control group consisting of patients between the ages of 50 and 84 years who had undergone appendectomy during the same 5-year period.

Results: Black patients had higher rates of femoral bypass than did white patients after adjustment for age and sex (odds ratio = 1.97; 95% confidence interval: 1.49, 2.61; $p < 0.0001$). However, femoral bypass was also associated with hypertension, diabetes, and low household income. After adjusting for these additional factors in the statewide data set, the black/white odds ratio for femoral bypass was only 1.44 (95% confidence interval: 1.08, 1.92). The parallel case-control study at University Hospital and Boston City Hospital, which provided information about smoking status and more accurate ascertainment of coexisting hypertension and diabetes, indicated that there was no racial difference in rates of femoral bypass after correcting for these additional risk factors (odds ratio = 0.94; 95% confidence interval: 0.40, 2.22; $p = 0.90$). In contrast, abdominal aortic aneurysmectomy occurred predominantly in white men. Aneurysmectomy was also associated with smoking and hypertension, but aneurysmectomy was not significantly associated with diabetes mellitus or family income. The black/white odds ratio for aneurysm was 0.29; (95% confidence interval: 0.07, 1.23; $p = 0.09$ after adjustment for other variables).

Conclusions: Hypertension, smoking, and male sex are risk factors for the development of femoral atherosclerosis and abdominal aortic aneurysm formation. However, abdominal aortic aneurysms occur predominantly in white men and do not appear to be associated with diabetes mellitus or income. In contrast, the higher rate of femoral artery bypass in black patients is probably the result of greater prevalence among black patients of hypertension, diabetes, smoking, and perhaps by other ill-defined factors associated with socioeconomic status. (J VASC SURG 1995;21:422-31.)

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Atherosclerotic disease appears to occur more frequently or with greater severity in black patients than in white patients. Black patients have a greater risk for development of cerebrovascular disease,[1-4] higher death rates from heart disease,[4] and more severe tibial artery atherosclerosis than do white patients.[5] Some of these differences may be attributed to racial differences in the distribution of certain risk factors for atherosclerosis, such as hypertension,[1,4,6] diabetes,[1] and smoking,[7] but the extent to which these risk factors account for racial differences in vascular disease is not clear.

In contrast to atherosclerotic occlusive disease, abdominal aortic aneurysms are reported to be less common in black patients than in white patients[8-10] despite the fact that aneurysms have traditionally been viewed as a consequence of atherosclerosis.[11-13] An atherosclerotic cause was supported by the frequent occurrence of atherosclerosis within these aneurysms and by the observation that male sex, smoking, hypertension, and advancing age are risk factors for atherosclerotic and aneurysmal diseases.[14] However, Tilson and Stansel[15] challenged the notion of an atherosclerotic cause for abdominal aortic aneurysms on the basis of their observations that aneurysms were more strongly associated with male sex and tended to occur a decade later than in patients with atherosclerotic occlusive disease.

We hypothesized that although atherosclerotic occlusive disease and aneurysmal disease share certain common risk factors, there are important qualitative and quantitative differences in risk factors for these two diseases, which indicate that their pathogenesis is substantially different. Thus the purpose of this study was to compare and contrast aneurysmal and atherosclerotic occlusive diseases by means of a multivariate approach that simultaneously examined associations with age, sex, hypertension, diabetes, and race. These relationships were explored with both a population-based approach and a nested case-control study, which used a large database containing hospital discharge data for all residents of Massachusetts from 1984 through 1988. Associations were explored further with a parallel case-control study based on a review of medical records at The University Hospital of Boston University Medical Center and Boston City Hospital (BCH/UH).

METHODS

Two data sources were used for this study: (1) hospital discharge summaries obtained from the Massachusetts Health Data Consortium, Inc. (Waltham, Mass.) and (2) medical records from BCH/UH.

Massachusetts Hospital discharge data. The database maintained by the Massachusetts Health Data Consortium, Inc., contains hospital discharge information for all patients residing in Massachusetts and includes age, sex, race, and codes from the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) for up to 10 diagnoses and 10 procedures for each hospitalization. We obtained records for patients with a valid Massachusetts zip code who were discharged between January 1984 and December 1988 with an ICD-9-CM procedure code for abdominal aortic aneurysm resection (38.44) or aneurysmorrhaphy (38.34) or with a procedure code for femoral artery bypass/reconstruction (39.29). To compare and contrast the risk factors associated with femoral bypass versus aneurysmal surgery, we examined the risk factors for each of these procedures by comparing them with a control group consisting of patients between the ages of 50 and 84 years who had undergone appendectomy during the same 5-year period. Patients undergoing appendectomy were selected for the comparison group because (1) appendectomies are relatively common, frequently incidental procedures performed in both men and women; (2) appendectomy is not known to be associated with peripheral vascular disease or risk factors for cardiovascular disease; and (3) the incidence of appendectomy is comparable in black and white adults (vida infra).

ICD-9-CM diagnostic codes were used to identify patients with hypertension (401.9) and insulin-dependent and non–insulin-dependent diabetes (250.01 and 250.00). Insulin-dependent diabetic patients and non–insulin dependent diabetic patients were pooled into a single group because of the relatively small number of diabetic subjects within subgroups.

Because the database does not contain unique patient identifiers, it was not possible to control for multiple admissions for a given patient. To control for socioeconomic status an estimate of median household income was assigned to each patient record on the basis of the zip code of residence recorded in the discharge summary. Estimates of median household income were taken from a census-derived sourcebook for the U.S. population.[16] Analysis was restricted to surgical procedures in black patients and white patients, ages 50 to 84 years (inclusive). (For this time period the overall racial distribution in Massachusetts was as follows: 93.4% white, 3.9% black, and 2.7% other or unknown. For the segment of the population ages 50 years or greater, white patients represented approximately 96% of Massachusetts population, whereas black patients constituted about 2.5% *[Annual report—vital statistics of Massachusetts, 1985].*)

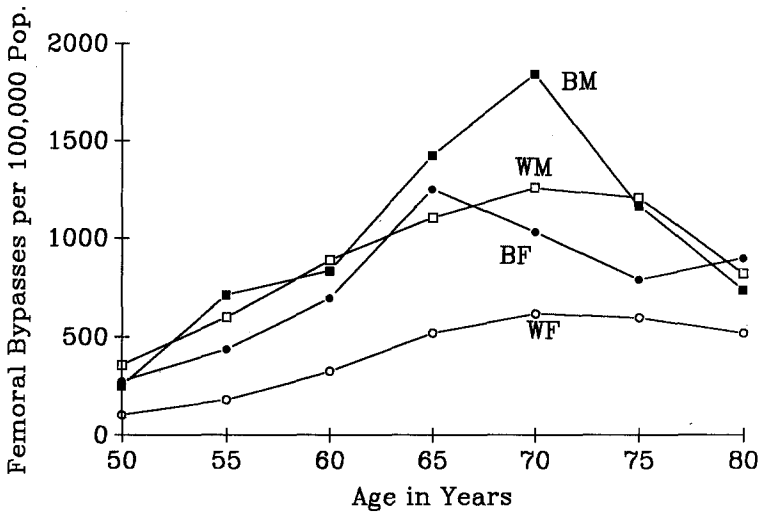

Fig. 1. Age-specific rates of femoral bypass surgery in Massachusetts for black and white men and women for entire 5-year period studied (1984 to 1988).

BCH/UH data. A review of medical records was conducted for patients ages 50 to 84 years who had undergone abdominal aortic aneurysmectomy, femoral bypass, or appendectomy (control subjects) at either BCH or UH between 1985 and December 1991. The chart review was approved by the institutional review boards at both hospitals. The charts were reviewed to verify diagnoses and procedures, and information was collected regarding age, sex, race, and potentially important covariates such as hypertension, diabetes, and smoking. Patients were classified as hypertensive, diabetic, or both on the basis of chart review indicating either diagnosis and the need for treatment with medication or diet. Because of the relatively small number of diabetic subjects within subgroups, insulin-dependent diabetic subjects and non–insulin dependent diabetic subjects were pooled into a single group. Patients were classified as smokers if review of the chart revealed evidence of significant past or present tobacco smoking.

Statistical analysis. From the Massachusetts statewide discharge data, rates for each of the three surgical procedures were calculated for black and white men and women. Adjustment for age was conducted with use of 5-year age intervals; for each interval race- and sex-specific population estimates were taken from 1980 census data reported in the *Annual report—vital statistics of Massachusetts, 1985.*

For both the statewide data and the Boston University Medical Center data, the effects of risk factors on femoral bypass or aneurysmectomy were explored by case-control analysis; first, subjects with abdominal aortic aneurysm were compared with the control group (patients who had undergone appendectomy for any reason), and then subjects undergoing femoral bypass were compared with the same control subjects who underwent appendectomy. For the case-control studies relative risk was estimated from the odds ratio, that is, the odds that the patients have a given risk factor relative to the odds that the control subjects have the same factor. Adjusted odds ratios were calculated with multiple logistic regression. Statistical procedures were conducted with SAS software licensed to Boston University.

RESULTS

The Massachusetts statewide database

Rates of femoral artery bypass in Massachusetts. There were 9909 discharge records for patients ages 50 to 84 years undergoing femoral bypass between 1984 and 1988. Fig. 1 shows age-specific rates of femoral bypass for black and white men and women for the entire 5-year period studied. In general rates of femoral bypass tended to increase up to age 70 to 74 years but then tended to decline somewhat. Men had higher rates of femoral surgery than did women, but there also appeared to be a racial difference. Between 65 and 74 years of age, when the highest rates were observed, black men had higher rates than did white men, and black women had higher rates of femoral bypass than did white women at all ages studied. Standardization of rates by the direct method indicated that the relative risk of femoral bypass in blacks compared with whites was 1.42. However, among men the black/white stan-

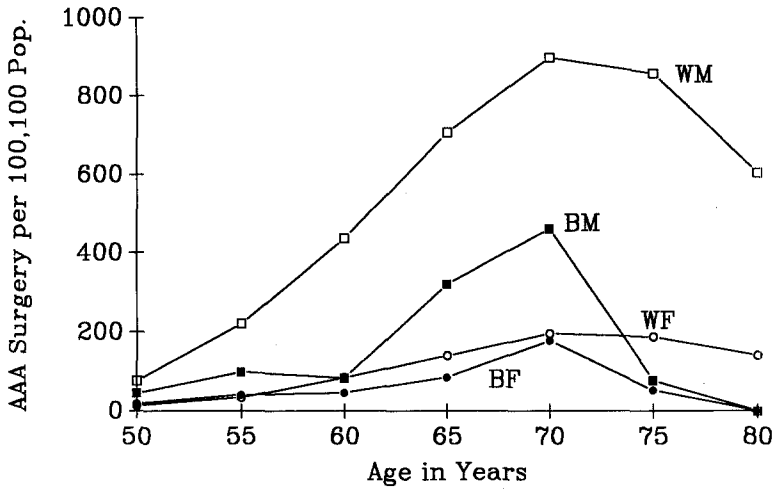

Fig. 2. Age-specific rates of abdominal aortic aneurysm surgery in Massachusetts from 1984 through 1988.

Table I. Multivariate analysis of risk factors for femoral bypass and abdominal aortic aneurysmectomy based on the Massachusetts Health Data Consortium database*

	Femoral artery bypass			*Abdominal aortic aneurysmectomy*		
Factor	*Odds ratio*	*95% CI*	*p Value*	*Odds ratio*	*95% CI*	*p Value*
Age	1.066/yr	(1.06, 1.07)	0.0001	1.09/yr	(1.08, 1.10)	0.0001
Male sex	1.57	(1.44, 1.71)	0.0001	2.90	(2.60, 3.23)	0.0001
Hypertension	2.10	(1.83, 2.42)	0.0001	3.13	(2.68, 3.66)	0.0001
Diabetes	2.76	(2.34, 3.26)	0.0001	0.78	(0.62, 0.98)	0.03
Estimated income	0.85/$10,000	(0.81, 0.89)	0.0001	1.01/$10,000	(0.93, 1.09)	0.80
Race (B/W)	1.44	(1.08, 1.92)	0.01	0.41	(0.26, 0.65)	0.0001

*Patients undergoing appendectomy were used as control subjects.

dardized relative risk was only 1.13 compared with 1.93 for women.

Rates of abdominal aortic aneurysmectomy in Massachusetts. During the 5-year study period, 4682 abdominal aortic aneurysmectomies were performed. Fig. 2, which illustrates age-specific rates of aneurysmectomy, shows a far different pattern of variation among black and white men and women than that seen with femoral surgery. Rates of aneurysmectomy were relatively low in both black and white women but tended to be somewhat greater in white women. Even more striking was the extraordinarily high frequency among white men, who accounted for 80% of the abdominal aortic aneurysmectomies. Standardization of rates by the direct method indicated that the risk of aneurysmectomy in black patients was 0.38 compared with white patients, with a black/white standardized relative risk of 0.33 in men and 0.56 among women.

Appendectomy rates among black and white men and women in Massachusetts. For all ages 29,371 appendectomies were performed in Massachusetts from 1984 through 1988. Not surprisingly, appendectomy rates were substantially higher in children and adolescents than in adults and tended to peak in the second decade. However, appendectomy rates among children and adolescents were consistently higher in white patients compared with black patients and consistently higher in men compared with women. These findings were remarkably similar to those recently reported that used a similar large database in California.[18]

There were 3188 appendectomies performed in persons between the ages of 50 and 84 years from 1984 through 1988. Appendectomy rates were relatively stable within this age-restricted group, and no consistent pattern of difference occurred among the four race and gender groups. For this age group, the standardized rate of appendectomy for black patients compared with white patients was 0.80 when calculated by the direct method.

Table II. Age, estimated income, and prevalence of hypertension and diabetes in patients undergoing femoral bypass, abdominal aortic aneurysmectomy, or appendectomy from the Massachusetts Health Data Consortium database

	Femoral bypass (n = 9909)				*Abdominal aortic aneurysmectomy (n = 4682)*	
	WM	*WF*	*BM*	*BF*	*WM*	*WF*
Sample size	5523	4061	144	181	3278	1363
Age ± SE	66.9 ± 0.1	69.8 ± 0.1	65.8 ± 0.6	66.6 ± 0.6	69.1 ± 0.1	71.0 ± 0.3
Hypertension (%)	16.5	20.2	28.5	34.3	20.3	28.5
Diabetes (%)	15.6	16.7	16.0	19.9	5.3	5.3
Estimated income	$34,915 ± 140	$34,483 ± 164	$25,558 ± 727	$24,708 ± 621	$36,536 ± 190	$35,527 ± 289

Table III. Age and prevalence of hypertension, diabetes, and smoking in patients undergoing femoral bypass, abdominal aortic aneurysmectomy, or appendectomy from the BCH/UH chart review

	Femoral bypass surgery (n = 278)				*Abdominal aortic aneurysmectomy (n = 102)*	
	WM	*WF*	*BM*	*BF*	*WM*	*WF*
Sample size	115	63	38	39	71	21
Age ± SE	66.6 ± 0.7	69.9 ± 1.1	65.8 ± 1.5	68.1 ± 1.5	68.8 ± 1.0	72.2 ± 1.8
Hypertension (%)	57	71	71	74	61	91
Diabetes (%)	44	54	50	67	7	10
Smoking (%)	93	60	90	64	93	81
Estimated income	$31,117 ± 1053	$30,553 ± 1248	$21,618 ± 724	$21,859 ± 940	$35,217 ± 1352	$35,453 ± 2310

Case-control analysis of factors associated with femoral bypass in Massachusetts. Logistic regression analysis was used to explore factors associated with the risk of femoral bypass by use of patients undergoing appendectomy who were 50 to 84 years old as control subjects. To examine the comparability between this case-control approach and calculation of standardized rates with the direct method, regression initially was carried out with only age, race, and sex as independent variables in the model. Overall the black/white odds ratio for femoral bypass was 1.97 (95% confidence interval: 1.49, 2.61; $p < 0.0001$). For men the black/white odds ratio was 1.32 (95% confidence interval: 0.90, 1.95; $p = 0.16$), whereas for women it was 2.76 (95% confidence interval: 1.86, 4.10; $p < 0.0001$). These estimates of effect, although somewhat greater, are similar to those calculated by direct standardization.

Table I summarizes a more extensive multivariate analysis, which also attempts to adjust for differences in hypertension, diabetes mellitus, and estimated income. Increasing age, male sex, and coexisting hypertension and diabetes were associated with femoral bypass. Even after adjusting for these factors, there was a significant association between estimated income and femoral bypass; the odds ratio of 0.85 per $10,000 suggests that lower income groups had a higher risk of bypass. The association between low income and femoral bypass was similar in black patients and white patients, because identical odds ratios were obtained when the analysis was stratified according to race. After adjusting for these factors, black patients were still at greater risk of femoral bypass than were white patients with an odds ratio of 1.44.

Case-control analysis of factors associated with abdominal aortic aneurysmectomy in Massachusetts. Factors associated with abdominal aortic aneurysmectomy were studied in a parallel fashion with the same group of appendectomy control subjects. Again, a limited regression model, which considered only age, race, and sex as independent variables, was initially explored. This model indicated that for aneurysmectomy, the black/white odds ratio was 0.53 (95% confidence interval: 0.35, 0.81; $p = 0.003$). For men the odds ratio was 0.38 (95% confidence interval: 0.22, 0.67; $p = 0.0008$), whereas for women it was 0.81 (95% confidence interval: 0.43, 1.51; $p = 0.51$). These estimates were also consistent with those calculated by direct standardization.

The results obtained when hypertension, diabetes, and estimated income were included in the regression model are shown in Table I. Age, male sex,

Abdominal aortic aneurysmectomy (n = 4682)		*Appendectomy (n = 3188)*			
BM	*BF*	*WM*	*WF*	*BM*	*BF*
23	18	1546	1579	32	31
66.2 ± 1.3	67.7 ± 2.2	62.9 ± 0.2	63.9 ± 0.2	61.9 ± 1.2	62.9 ± 2.3
43.5	50.0	8.0	9.8	15.6	22.6
4.3	5.6	5.9	5.4	21.9	3.2
$27,360 ± 2445	$25,100 ± 1802	$37,024 ± 289	$35,801 ± 267	$25,303 ± 1451	$28,141 ± 1635

Abdominal aortic aneurysmectomy (n = 102)		*Appendectomy (n = 37)*			
BM	*BF*	*WM*	*WF*	*BM*	*BF*
7	3	13	14	4	6
68.7 ± 3.7	70.7 ± 1.5	61.9 ± 1.9	68.3 ± 3.5	60.8 ± 2.9	62.5 ± 3.8
86	100	54	43	50	83
0	33	15	21	0	17
67	67	90	42	75	33
$20,654 ± 1673	$18,048 ± 439	$35,107 ± 3085	$26,062 ± 1781	$33,040 ± 7353	$20,605 ± 1671

and hypertension were significantly associated with aneurysmectomy, but for each the estimate of effect was greater than it was for femoral bypass. In marked contrast to what was found for femoral bypass, diabetes was not a risk factor for aneurysmectomy. In fact the odds ratio of 0.78 for diabetes suggests that if anything diabetic subjects appear to have lower risk of aneurysmectomy relative to appendectomy. Another important difference between patients undergoing aneurysmectomy versus femoral bypass was that estimated income showed no association with aneurysmectomy (odds ratio = 1.01). This lack of association with income was also seen when the analysis was repeated after stratifying by race. For white patients the odds ratio for income was 1.01 per $10,000 (95% confidence interval: 0.94, 1.09); for black patients the odds ratio for income was 0.97 (95% confidence interval: 0.86, 1.14). After adjusting for other differences, the black/white odds ratio was 0.41.

A nested case-control study based on review of hospital records

Prevalence of cardiovascular risk factors. Because of the lack of information regarding smoking status and concerns of possible underreporting of hypertension and diabetes in the discharge summaries, we used the same ICD-9 selection criteria to identify patients at BCH or UH who had one of these three surgical procedures during the same time period.

Age and prevalence of hypertension and diabetes are shown in Tables II and III for each surgical procedure. Table II summarizes data obtained from the Massachusetts Health Data Consortium, and Table III reports the corresponding findings based on the chart reviews at BCH/UH. Comparison of Tables II and III suggests several observations. First, the mean ages for the various groups in the statewide study are very similar to those in the corresponding groups at BCH/UH. Second, the prevalence of hypertension and diabetes estimated by the BCH/UH chart review was greater than that found in the statewide discharge summaries. Tables II and III also report estimated household income. For each of the three surgical procedures estimated household income tended to be greater for white patients, but income did not appear to differ on the basis of the type of surgical procedure or sex.

BCH/UH case-control analysis of factors associated with femoral bypass. The analysis conducted for the BCH/UH database paralleled that for the statewide database in that regression initially was carried out with only age, race, and sex as indepen-

Table IV. Multivariate analysis of risk factors for femoral bypass and abdominal aortic aneurysmectomy based on the BCH/UH chart review

	Femoral artery bypass			*Abdominal aortic aneurysmectomy*		
Factor	*Odds ratio*	*95% CI*	*p Value*	*Odds ratio*	*95% CI*	*p Value*
Age	1.05/yr.	(1.00, 1.10)	0.04	1.09/yr.	(1.03, 1.15)	0.003
Male gender	1.74	(0.70, 4.30)	0.23	5.82	(1.78, 19.03)	0.004
Hypertension	1.49	(0.65, 3.43)	0.35	3.56	(1.15, 11.00)	0.03
Diabetes	7.71	(2.61 22.77)	0.0002	0.46	(0.11, 1.99)	0.30
Smoking	5.37	(1.89, 15.24)	0.002	2.41	(0.67, 8.71)	0.18
Estimated income	0.86/$10,000	(0.57, 1.29)	0.47	1.20/$10,000	(0.75, 1.93)	0.45
Race (B/W)	0.94	(0.40, 2.22)	0.90	0.29	(0.07, 1.23)	0.09

*Patients undergoing appendectomy were used as control subjects.

dent variables in the model. This analysis also indicated that age and male sex were significantly associated with the risk of femoral bypass. After adjusting for these factors, the black/white odds ratio was 1.55 (95% confidence interval: 0.76, 3.16; $p = 0.23$). The association with race was not statistically significant with this limited sample size, but the magnitude of the estimate of effect for race was very similar to the comparable estimate obtained in the analysis of the statewide data.

Table IV summarizes results of multivariate analysis of the chart review when covariates for hypertension, diabetes, and smoking were also included in the regression model. The odds ratios for age and sex, for which misclassification would not be expected to be a major problem, were very similar to the comparable odds ratios reported in Table I. In contrast, diabetes was much more strongly associated with risk of femoral bypass than had been suggested by the statewide analysis. Furthermore, analysis of the BCH/UH chart review also suggested that smoking, a variable that was unavailable in the statewide analysis, was strongly associated with risk of femoral bypass. However, after adjusting for differences in age, sex, hypertension, diabetes, smoking, and estimated income, the black/white odds ratio was near unity, which suggests that race was not an independent risk factor for femoral bypass.

BCH/UH case-control analysis of factors associated with abdominal aortic aneurysmectomy. Multivariate analysis of the BCH/UH chart review with the limited regression model suggested that after adjusting for age and sex, black patients had less risk of abdominal aortic aneurysmectomy than did white patients (odds ratio = 0.38; 95% confidence interval: 0.13, 1.14; $p = 0.08$). This finding was very similar to comparable estimates in the statewide data calculated by direct standardization of rates or by logistic regression.

Table IV also summarizes results of multivariate analysis of the chart review with covariates for hypertension, diabetes, and smoking in the regression model. After adjusting for other factors, male sex and hypertension were strongly associated with aneurysmectomy. There also appeared to be an association between smoking and aneurysmectomy, although the confidence interval was wide. After adjusting for all other variables, the black/white odds ratio was 0.29, which indicates a substantially lower risk of aneurysmectomy for black patients than for white patients.

DISCUSSION

Several conclusions can be drawn from this study. First, the rates of femoral bypass are higher for black patients than white patients in Massachusetts, particularly for women. However, the higher rates of femoral occlusive disease may be the result of greater prevalence of certain risk factors in the black population; after adjusting for differences in age, gender distribution, hypertension, diabetes, and smoking, the risk of femoral artery occlusive disease appeared to be similar in black patients and white patients. Second, abdominal aortic aneurysm resections were far more common in white men than in the other race-gender groups that were studied, which is consistent with previous hypotheses suggesting a genetic component in their pathogenesis. Third, although both abdominal aortic aneurysms and femoral arterial occlusive disease have traditionally been thought of as manifestations of atherosclerosis, there are substantial epidemiologic differences in associated risk factors, which suggest important differences in the pathogenesis of these two vascular diseases.

Identification of study samples of adequate size was a major obstacle to defining factors associated with these peripheral vascular diseases. Abdominal

aortic aneurysms are relatively uncommon and even when present are usually asymptomatic. Femoral artery atherosclerosis is more common but is also asymptomatic in its early stages. Consequently, for both conditions the performance of specific surgical procedures was used as a marker of clinically significant disease. The use of ICD-9 procedure codes was probably a reasonably accurate way to identify subjects with aortic aneurysms or clinically significant femoral atherosclerosis. These conditions certainly represent the most common indications for this type of surgery. Some of the aortic cases may actually be patients who underwent aortic surgery for other conditions such as trauma or obstructive disease, and some of the femoral bypasses may have been done for reasons other than femoral artery atherosclerosis. However, given the usual indications for performing these procedures and the relative specificity of the codes used, it is likely that most of the cases identified were patients with the disease of interest.

A certain amount of miscoding of diagnoses and procedures is inherent in large databases of this type, and errors probably occurred in recording the other variables of interest as well. Misclassification of age, sex, and race probably occurred in a relatively small percentage of cases and most likely did not have any major impact. In contrast, failure to record the presence of coexisting hypertension and diabetes was probably common in these patients who were admitted primarily for surgical procedures, as suggested by their greater prevalence in the BCH/UH chart review. Nevertheless, this random misclassification does not undermine the validity of our findings, because its effect, if any, would be to produce an underestimation of the importance of these variables. Thus the relatively minor problem of random misclassification in the discharge summaries was far outweighed by the enormous power that they provided.

In contrast to the statewide study, the BCH/UH chart review entailed a relatively small number of patients and did not provide great statistical power. However, the BCH/UH phase of the study complemented the statewide study in an important way by allowing us to confirm associations with use of a data set with diagnoses that could be confirmed and that was relatively free of misclassification bias. Consequently, the nearly eightfold greater risk of femoral bypass among diabetic subjects suggested by the BCH/UH chart review may be more indicative of the true impact of diabetes on femoral atherosclerosis. In addition, the chart review enabled us to assess the association between these peripheral vascular diseases and smoking. Consequently, the statewide analysis and the BCH/UH chart review were complementary; the first provided great statistical power and the second provided more verifiable diagnoses and more complete information about important covariates.

One problem common to both the chart review and the analysis of statewide data is that differences in access to medical care on the basis of race or socioeconomic status could have resulted in selection bias, particularly for patients with aneurysms. Selection bias is unlikely to account for the observed racial differences in rates of femoral bypass. First, the usual indications for femoral bypass are ischemic ulceration or gangrene, rest pain, or debilitating claudication. Given the severity of these indications, it is likely that most candidates for femoral bypass would come to the attention of the medical establishment and be treated appropriately regardless of socioeconomic status or access to medical care. Second, selection bias would be expected to result in lower rates of femoral revascularization in black patients, but just the opposite was observed. Similar findings were recently reported by Tunis et al.,[19] who found that the age-adjusted likelihood of having a procedure for peripheral arterial disease was 1.6 times higher in black patients than in white patients. They examined not only bypasses but also angioplasties and amputations; their findings indicated that no racial differences were observed in the type of surgery performed for clinically significant occlusive disease. Finally, it is also interesting to note that femoral bypass was significantly associated with lower estimated household income in both black and white patients, which is consistent with previous reports indicating an inverse relationship between socioeconomic class and mortality rates.[20-22]

In contrast to femoral bypass, however, most abdominal aortic aneurysms are asymptomatic and are discovered during physical examination or abdominal imaging for other reasons. Therefore it is possible that persons with limited access to regular health care would be less likely to have an aneurysm diagnosed and repaired. Nevertheless, selection bias probably does not account for the greater rates of aneurysm surgery in whites for several reasons. First, greater risk of aneurysmectomy in whites was primarily because of the extraordinarily high rates in white men; black and white women actually had similar rates of aneurysm repair (Fig. 2). Second, failure to diagnose or treat aneurysms in blacks would be expected to produce higher aneurysm mortality rates among black patients. However, Fig. 3 shows mortality rates of aneurysms in the United States for

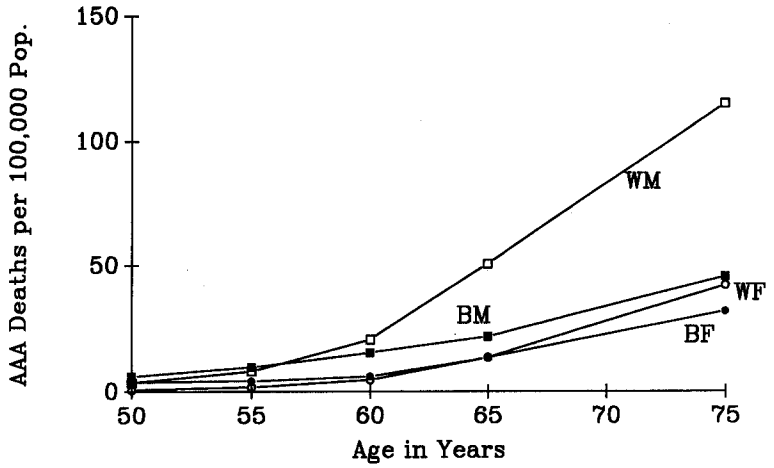

Fig. 3. Age-specific mortality rates attributed to abdominal aortic aneurysms in United States. (From Health, United States, 1985. Hyattsville, Maryland: National Centre for Health Statistics, 1986; DHHS publication no. [PHS] 86-1232.)

the study period and demonstrates that white men also have the highest mortality rates resulting from abdominal aortic aneurysms. A final observation suggesting that selection bias was not responsible for higher rates of aneurysm surgery in white patients is that the likelihood of aneurysm surgery was not related to estimated household income.

Although many studies have documented higher mortality and morbidity rates among lower socioeconomic classes, the reasons for this remain unclear.[23] Although it has frequently been assumed that poorer health in lower socioeconomic strata is due to racial differences, there is increasing evidence that this is usually not the case and that low socioeconomic status is a proxy for other factors that have a direct impact on health.[23] Our findings with respect to rates of femoral bypass support this hypothesis. Crude analysis suggested higher rates of femoral bypass in black patients, but the risk of femoral surgery was similar after adjusting for differences in age, hypertension, diabetes, smoking, and income. In contrast, aneurysm surgery was substantially more common in white patients (and white men in particular) even after adjusting for hypertension and smoking, and the risk of aneurysm surgery was unaffected by estimated income or type of insurance. It should be noted, however, that our search for risk factors was limited, and we did not examine the role of other putative risk factors, such as emphysema. It might also be argued that our use of median household income by zip code was not an accurate estimate of income for persons. Although this is true, median household income by zip code probably does provide a reasonably legitimate marker of "socioeconomic status," particularly in a large population-based study like this one and provides a means of exploring (and controlling for) the potential impact of socioeconomics.

Although hypertension, smoking, and male sex appear to be risk factors for the development of both femoral atherosclerosis and an abdominal aortic aneurysm, substantial differences exist in the epidemiology of these conditions. The markedly greater risk of aneurysmectomy among white men may be the result of genetic factors, as others have suggested.[24-27] However, the excess risk of peripheral vascular atherosclerosis among black patients is probably explained in large part by differences in hypertension, diabetes, smoking, and perhaps by other ill-defined factors associated with socioeconomic status.

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