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## Prevalence of Cardiovascular Events in Patients with Autosomal Dominant Polycystic Kidney Disease

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### Abstract

**Background**—This study evaluates the prevalence of cardiovascular events in autosomal dominant polycystic kidney disease (ADPKD) patients.

**Methods**—We distributed surveys to 1439 subjects from our ADPKD research database. 426 subjects with ADPKD completed and returned surveys. Seven of 426 surveys returned were children and were excluded from the study.

**Results**—ADPKD patients responding were female (63.2%), non-Hispanic (88.1%) and white (93.6%). The mean age of total group was  $53.2 \pm 13.7$  years. 82.8% had a family history of ADPKD and 32.5% had reached end-stage renal disease (ESRD). With respect to cardiovascular risk factors 86.6% were hypertensive with a mean age at diagnosis of  $36.9 \pm 12.9$  years and hypertension was significantly more prevalent in males. In addition, 19.6% of subjects were obese, 20.8% were smokers, 8.7% had diabetes, 45.7% had high cholesterol and 17.8% were sedentary. The most prevalent self reported cardiovascular events were arrhythmias (25.9%), evidence of peripheral vascular disease (16.5%), heart valve problems (14.4%), cardiac enlargement (9.5%), stroke or cerebral bleeding (7.5%), myocardial infarction (6%) and brain aneurysm (5.0%). The most commonly used antihypertensive medications were renin-angiotensin inhibitors used by 75% of ADPKD patients. Older ADPKD patients and those at ESRD had a significantly higher incidence of cardiovascular events.

**Conclusion**—These findings support the high prevalence of cardiovascular risk factors and events in ADPKD patients and thus increasing risk for mortality. Due to the prevalence of cardiovascular risk factors in the ADPKD population, early diagnosis and clinical intervention are recommended.

### Keywords

Autosomal dominant polycystic kidney disease; cardiovascular events; risk factor; morbidity; mortality

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**Disclosures**  
None

## Introduction

Approximately 6 million Americans have combined chronic cardiovascular and kidney disease resulting in an increasing epidemic of heart and kidney failure [1]. This morbid association represents unique challenges to the clinician. Approximately 600,000 Americans are affected with autosomal dominant polycystic kidney disease (ADPKD), with over 2000 patients starting dialysis every year [2]. Patients with ADPKD have an increased incidence of early onset hypertension, left ventricular hypertrophy (LVH) and cardiovascular abnormalities [3, 4]. The reported relative mortality rate in patients with ADPKD ranges between 1.6 fold (95% confidence interval, 1.3 to 2.0) and 3.2 folds higher (95% confidence interval, 2 to 4.8) in comparison with the general population [5].

Cardiovascular complications are the most common cause of morbidity and mortality in patients with ADPKD [6]. Primary prevention therefore is important to reduce early morbidity and mortality. Thus there is a need for detection and treatment of cardiovascular risk factors in the ADPKD population. There is evidence that blockade of the renin-angiotensin-aldosterone system (RAAS) with better control of blood pressure has improved ADPKD patient and renal survival [7–9]. There also are results in hypertensive ADPKD patients which demonstrate that initial therapy with RAAS inhibition as compared to diuretics necessitates significantly fewer antihypertensive medications for comparable control of blood pressure [10].

The present study analyzed the cardiovascular events and risk factors in a large number of ADPKD patients according to gender, age, hypertension, cholesterol, smoking and end-stage renal disease (ESRD). This observational study was undertaken in an era in which the majority of patients were receiving RAAS inhibition.

## Methods

### Data source and study population

We developed a 6-page survey that was distributed to 1439 study subjects listed as having ADPKD in our database. The survey asked basic demographic questions and specific questions related to occurrence of cardiovascular disease in ADPKD patients, including occurrence of stroke, peripheral arterial disease, abdominal aortic aneurysm, angina pectoris, myocardial infarction, atrial or ventricular arrhythmias, left ventricular hypertrophy, and cardiac valvular abnormalities. The survey also collected information regarding the presence and treatment of cardiovascular risk factors, including hyperlipidemia, smoking, diabetes mellitus, hypertension, and medication use.

The survey was sent in a single mailing (January 2011) with instructions to return the survey using a provided return envelope. 426 subjects with ADPKD (30%) returned the survey completed. Out of 426 surveys returned, 7 were from patients under the age of 18 and were excluded from the analysis.

## Statistical analysis

SAS version 9.3 PROC FREQ and PROC MEANS were used to obtain descriptive statistics for the surveys. The difference between the distribution of age categories for men and women was tested using a contingency table Chi-square test. For this test  $p < 0.05$  was considered significant.

Proportions for demographics were calculated as a percentage of all respondents. Proportions for other tables were calculated as a percentage of those who responded to that question.

Because multiple outcomes were tested, p-values were adjusted using the Bonferroni method. Adjusted p-values less than 0.0036 ( $0.05 / 14$ ) or unadjusted p-values of less than 0.05 were considered significant. This adjustment corrects for the probability of getting a significant p-value purely by chance.

## Results

### Descriptive analysis of ADPKD patients responding

ADPKD patients responding were female (63.2%), non-Hispanic (88.1%) and white (93.6%) (Table 1). The mean age of the total group was  $53.2 \pm 13.7$  years. 82.8% had a family history of ADPKD and 32.5% had reached ESRD. Among respondents analysis of cardiovascular risk factors (Table 2) demonstrated that 86.6% had hypertension with mean age of diagnosis of  $36.9 \pm 12.9$  years with significantly higher prevalence in males, 19.6% were obese, 20.8% were smokers, 8.7% had diabetes, 45.7% had high cholesterol and 17.8% were sedentary. The most prevalent self reported cardiovascular events (Table 3) were arrhythmias (25.9%) with mean age of diagnosis of  $43.3 \pm 16.4$  years, evidence of peripheral vascular disease (16.5%) with mean age of diagnosis of  $45 \pm 13$  years, heart valve problems (14.4%) with mean age of diagnosis of  $41.2 \pm 16.5$  years, cardiac enlargement (9.5%) with mean age of diagnosis of  $42.6 \pm 13.9$  years, stroke or cerebral bleeding (7.5%) with mean age of diagnosis of  $50.8 \pm 13.4$  years, myocardial infarction (6%) with mean age of diagnosis of  $53.4 \pm 9.6$  years and brain aneurysm (5.0%) with mean age of diagnosis of  $43.4 \pm 13.7$  years. Angiotensin converting enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARBs) were used in 75% of hypertensive ADPKD patients (Table 4). Statins and anti-platelet medications (aspirin) were used in 11 % and 22.5 % respectively.

### Sub-groups analysis

Demographic parameters or cardiovascular risk factors were not significantly different between males and females (Table 5). The occurrence of reported heart attacks was significantly higher in males (11.4%) compared to females (3.1%) (Adjusted p-value of 0.0136) (Table 4).

ADPKD respondents over the age of 45 were significantly more likely to report hypertension and high cholesterol than those 45 or under (Table 6). Cardiovascular events were higher in older ADPKD respondents but did not reach significance (Table 6).

ADPKD respondents with ESRD were significantly more likely to report diabetes, hypertension, and high cholesterol levels (Table 7). They also reported significantly higher incidence of stroke or cerebral bleeding, heart attack, and cardiac enlargement (Table 7).

## Discussion

The most common extra-renal complications that contribute to morbidity and mortality in ADPKD patients are of cardiovascular nature [4]. Hypertension is the most frequent cardiovascular complication in ADPKD and contributes to both an increased incidence of cardiovascular mortality and faster progression to ESRD [6, 11, 12]. Hypertension develops early in the course of ADPKD [13] and occurs in 50 – 70 % of ADPKD patients with normal kidney function [14,15]. Previously we have reported a median age at diagnosis of hypertension in ADPKD of 32 years in males and 34 years in females [16]. The current results support the presence of early hypertension in ADPKD. Hypertension is a widespread feature of this disease and has been reported in up to 80% of ADPKD patients with ESRD on dialysis [17]. Thus, the main and most effective therapy in ADPKD remains control of hypertension primarily by including RAAS inhibition [7, 8]. The definitive answer of whether treatment with either ACEIs or / and ARBs results in decreased rate of renal disease progression in ADPKD awaits the results of the HALT-PKD study [18]. However, it is important to control hypertension in ADPKD patients since it is a specific risk factor for intra-cerebral hemorrhage and aneurysm ruptures [19].

Our study demonstrates a high prevalence of cardiovascular risk factors including hypertension, obesity, diabetes and hypercholesterolemia in ADPKD population. In a previous study 22% of ADPKD patients (age  $35.9 \pm 11.1$  years) with normal kidney function also fulfilled the International Diabetes Federation criteria of metabolic syndrome [20].

LVH is a significant risk factor for cardiovascular morbidity and mortality and a common finding in hypertensive and even normotensive ADPKD patients [21–24]. However, a recent study in ADPKD patients with preserved renal function reported a prevalence of LVH of 3.9 % (25). Increased left ventricular mass index does occur in children and young adults with ADPKD [13, 26–28]. The early onset of hypertension in ADPKD may be associated with LVH in nearly 50% of ADPKD patients by their 40s [22]Increased LVMI has been found to be associated with poor renal and overall outcomes in ADPKD patients [12]. A significant correlation between hypertension and increased LVMI has been demonstrated in both children and adults with ADPKD [13, 26–28]. RAAS inhibition in hypertensive ADPKD patients has led to long-term reversal of LVH [29,30]. This finding was significantly greater in association with rigorous control of blood pressure (< 120/80 mmHg) in ADPKD patients [30].

Structural cardiac abnormalities are found more often in ADPKD patients than in non-ADPKD family members or normal controls [31]. A prospective echocardiographic study in ADPKD subjects found mitral valve prolapse in 26% and mitral regurgitation in 31% [27]. Tricuspid regurgitation and aortic regurgitation also were found in 15% and 8%,

respectively (29). In the current ADPKD study overall heart valve problems were found in 14.4% of patients.

The occurrence rate of coronary events, such as angina, myocardial infarction, and need for coronary revascularization in ADPKD patients with normal renal function has not been previously reported in the literature. Our survey reported that 3.3% of respondents had angina, 6% had suffered a heart attack and 5.9 % had undergone angioplasty, angioplasty and stent or cardiac valve surgery. The mean age of heart surgery was  $50.7 \pm 11.9$  years. ADPKD patients with ESRD had less coronary events than matched ESRD patients of other causes [32, 33]. This has been attributed to less severe anemia in ADPKD patients [32, 33]. This is probably due to increased endogenous erythropoietin production in ADPKD patients [34].

Arterial aneurysms, particularly intracranial aneurysms, are more prevalent in ADPKD patients than in the general population (4.0–11.7% versus 1.0%) [35, 36]. Moreover, it has been suggested that ADPKD is a risk factor for coronary artery aneurysms [37]. Abdominal aortic aneurysm also appears to be more prevalent in ADPKD patients [38, 39]. The incidence of abdominal aortic aneurysm in our cohort was very low (0.8%). However, a tendency towards larger aortic diameters in ADPKD patients compared to a control population has previously been reported [39].

The other major vascular abnormality in ADPKD is intracranial aneurysms (ICA). The prevalence ranges from 5% in patients with no family history of ICA to 21% in those with a positive family history of ICA rupture [32, 35, 41]. The prevalence may be even higher in ADPKD patients on dialysis, as observed in our study. An occurrence rate of both asymptomatic and ruptured ICA of 33.3 % has been reported in ADPKD patients with ESRD [42]. Another study [43] found no difference in incidence of cerebrovascular accidents (CVAs) between ADPKD patients on dialysis and a non-PKD dialysis patient population. Only 25–50% of CVAs in ADPKD patients have been reported to result from ICA rupture [6, 44]. In our cohort the prevalence of brain aneurysms and stroke or intracerebral bleeding were respectively 5% and 7.5%. ICA rupture accounts for a 35–55% risk of combined morbidity and mortality [19, 45], thus, identification and screening of patients at risk for developing symptomatic ICA are recommended. Systematic screening of ICA with 3-dimensional magnetic resonance angiography (MRA) is recommended for ADPKD patients, particularly for adult patients (> 30 years), with a positive family history of hemorrhagic stroke or ICA, patients undergoing major surgery with potential hemodynamic instability and those at high risk occupations [46, 47]. MRA has been recommended every 5 years if initially negative and every 2–3 years if positive [46]. However, recent data support less requirement for screening for ICAs in ADPKD patients, and therefore widespread screening is not indicated [48].

Patients with non-PKD chronic kidney disease are at significantly increased cardiovascular events and risk factors [49]. However, ADPKD is unique by early occurrence of hypertension, heart valve problems and ICA. As expected, older ADPKD patients and those with ESRD are at higher risk for cardiovascular events. However, male gender may be losing its importance as a risk factor for cardiovascular events in ADPKD. The early and

effective treatment of hypertension in ADPKD is critical in the prevention of cardiovascular events in ADPKD.

## Conclusion

There are intrinsic limitations to the survey based nature of this study and the reported frequencies may be underestimated. Nevertheless, these present findings confirm the high prevalence of cardiovascular risk factors and events in ADPKD patients which are associated with increased risk for mortality. Moreover, older ADPKD subjects and those with ESRD had an increased risk for cardiovascular events, and this increased morbidity and mortality. Due to the prevalence and early onset of cardiovascular risk factors in the ADPKD population, early diagnosis and intervention by aggressively treating blood pressure in ADPKD patients is important to prevent LVH, cardiovascular complications, and mortality.

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## Appendix. Survey on Polycystic Kidney Disease (PKD)

Please mark answers with an X or fill in the information in the box as indicated. By returning this form, I indicate my consent to participate in this survey. Information will be kept strictly confidential. Feel free to attach a sheet of paper if needed to clarify an answer.

Date: \_\_\_\_\_

1. Name: \_\_\_\_\_

(Last) (First) (Middle)  
(Maiden)

2. Date of birth: □□ □□ □□□□

Month Day Year

3. Gender:  Male  Female

4. Ethnic categories (select one):

- Hispanic or Latino  Unknown  
 Not Hispanic or Latino  Decline to report  
 Decline to report

5. Racial categories (select one):

- American Indian/Alaska Native  White  
 Asian  More Than One Race  
 Native Hawaiian or other Pacific Islander  Unknown  
 Black or African American  Decline to report

6. Do you have other family members with PKD?  Yes  No  Unknown

7. Have you had either hemodialysis or peritoneal dialysis treatment?  Yes  No

If yes, what was your age at the time you had your first dialysis treatment? □□

8. Have you received a kidney transplant?  Yes  No

If yes, what was your age at the time of your first transplant? □□

9. Weight (pounds) □□□ Height (feet) □□.□

10. Have you ever smoked Cigarettes or Cigars:  Yes  No

If yes: How many packs/day: □□ Number of years you have smoked: □□

Do you still smoke?  Yes  No

11. Have you ever been told by a doctor that you have diabetes?

Yes  No If yes, what was your age at diagnosis? □□

If yes, Type:  1  2  Gestational  Unknown

(only during pregnancy)

If yes, initial treatment:  Diet  Medication  Insulin injection

If yes for medication(s), which diabetes medication(s) do you take?

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Current diabetes treatment (if different from above):

- Diet       Medication       Insulin injection

What was your age when you began your current treatment?

If yes for medication(s), which diabetes medication(s) do you currently take?

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**12. Have you ever been told by a doctor that you have high blood pressure**

- Yes       No      If yes, what was your age at diagnosis?

Have you been on medication for high blood pressure ?  Yes       No

If yes, which high blood pressure medication(s) do you take?

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**13. Have you ever been told by a doctor that you have high cholesterol?**

- Yes       No      If yes, what was your age at diagnosis?

Current treatment:  Diet       Medication

If yes for medication, which high cholesterol medication(s) do you take?

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14. **Do you exercise?**  Yes  No If yes, how many hours/week?

What type of exercise?  Walking  Running  Biking  Other

15. **Have you ever been told by a doctor that you had a stroke or bleeding in your head?**

Yes  No If yes, what was your age at diagnosis?

What was the problem (Mark all that apply)?

Symptoms of stroke lasting less than 24 hours  Stroke

Bleeding  Ruptured Aneurysm

16. **Have you ever been told by a doctor that you have a brain aneurysm?**

Yes  No If yes, what was your age at diagnosis?

If yes, have you ever had surgery for your aneurysm?  Yes  No

17. **Has anyone in your family been told by a doctor that they have a brain aneurysm or had a ruptured aneurysm in their head?**

Yes  No  Unknown

If yes, what was their age at diagnosis?

How are they related to you? \_\_\_\_\_

If yes, what was their age at diagnosis?

How are they related to you? \_\_\_\_\_

If yes, what was their age at diagnosis?

How are they related to you? \_\_\_\_\_

18. **Have you ever had circulation problems in your legs?**

Yes  No If yes, what was your age when this first occurred?

19. **Have you ever been told by a doctor that you had an abdominal aortic aneurysm?**

Yes  No If yes, what was your age at diagnosis?

20. **Have you ever been told by a doctor that you have Angina?**

Yes  No If yes, what was your age at diagnosis?

21. **Have you ever been told by a doctor that you had a heart attack?**

Yes  No If yes, what was your age at diagnosis?

22. **Have you ever been told by a doctor that you have an irregular heart beat?**

Yes  No If yes, what was your age at diagnosis?

23. **Have you ever been told by a doctor that you have an enlarged heart?**

Yes  No If yes, what was your age at diagnosis?

24. Have you ever been told by a doctor that you have a heart valve problem?

Yes  No If yes, what was your age at diagnosis?

25. Have you ever had heart surgery?  Yes  No

If yes:  Angioplasty  Stents  Angioplasty+Stent  Coronary bypass

If yes, what was your age at surgery?

26. If working, how many days have you missed work in the last year due to symptoms related to your PKD? \_\_\_\_\_

27. Have you ever been told by a doctor that you have osteoporosis?

Yes  No If yes, what was your age at diagnosis?

28. Have you ever been told by a doctor that you have low vitamin D?

Yes  No If yes, what was your age at diagnosis?

29. Have you ever been told by a doctor that you had kidney stones, or other problems from kidney stones?

Yes  No If yes, what was your age at diagnosis?

In one kidney  In both kidneys

How were the kidney stones treated?  Surgery  Medication  Other

If yes for medication, which medication(s) did you take for your kidney stones?

\_\_\_\_\_

30. What were your symptoms of kidney stones (mark all that apply):

Back Pain  Flank/Side Pain  Abdominal/Stomach Pain

Bloody Urine  A doctor found blood in my urine

Kidney infection  Abnormal laboratory or radiology results

31. Do you know what kind of stone you had?

Uric acid stone  Calcium containing stone  Unknown

32. Any other Medical Conditions not mentioned above?

\_\_\_\_\_  
\_\_\_\_\_

33. Are you currently taking prescription or over the counter medication(s) or vitamins?

Yes  No, not currently taking medication  Decline to report

Please list all current medicine(s) and the first date on which you started taking this medicine:

\_\_\_\_\_  
Name of Medication Date Began Taking  
Medication

\_\_\_\_\_  
Name of Medication Date Began Taking  
Medication

**Table 1**

Demographic characteristics of 419 survey respondents with ADPKD

Variable	N	% of Total (419)
Sex		
Male	145	34.6%
Female	265	63.2%
Not reported	9	2.2%
Ethnicity		
Hispanic or Latino	18	4.3%
Not Hispanic or Latino	369	88.1%
Unknown or not reported	32	7.6%
Race		
American Indian / Alaska Native	3	0.7%
Asian	3	0.7%
Black or African American	3	0.7%
White	381	93.6%
More than one race	12	3.0%
Unknown or not reported	17	4.1%
Family history of ADPKD		
No	347	82.8%
Unknown	37	8.8%
Unknown	35	8.4%
ESRD		
No	136	32.5%
Unknown	271	64.7%
Unknown	12	2.9%
Hemodialysis or peritoneal dialysis		
No	83	19.8%
Unknown	329	78.5%
Unknown	7	1.7%
Transplantation		
No	117	27.9%
Unknown	291	69.5%
Unknown	11	2.6%
Dialysis and transplantation		
Preemptive transplantation (never on dialysis)	66	16%
Preemptive transplantation (never on dialysis)	51	12.2%
		Mean ± SD
Age at time of survey	418	53.2 ± 13.7

ADPKD, autosomal dominant polycystic kidney disease; ESRD, End-stage renal disease.

**Table 2**

Incidence of cardiovascular risk factors in 419 survey respondents with ADPKD

<b>Variable</b>	<b>N</b>	<b>Percent</b>
Obesity (BMI $\geq 30$ )	77 / 392	19.6%
Ever smoked	156 / 412	37.9%
Current Smoker	32 / 154	20.8%
Diabetes	36 / 412	8.7%
Hypertension	356 / 411	86.6%
High cholesterol	188 / 411	45.7%
Sedentary	73 / 411	17.8%

ADPKD, autosomal dominant polycystic kidney disease; BMI, Body mass index

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**Table 3**

Prevalence of cardiovascular events 419 survey respondents with ADPKD

<b>Variable</b>	<b>N</b>	<b>%</b>	<b>Age at Diagnosis Mean <math>\pm</math> SD</b>
Stroke or cerebral bleeding	31 / 412	7.5%	50.8 $\pm$ 13.4
Brain aneurysm	20 / 397	5.0%	43.4 $\pm$ 13.7
Circulation problems in legs	66 / 400	16.5%	45 $\pm$ 13
Abdominal aortic aneurysm	3 / 397	0.8%	35.7 $\pm$ 26.8
Angina	13 / 399	3.3%	48.9 $\pm$ 15.9
Heart attack	24 / 399	6%	53.4 $\pm$ 9.6
Irregular heart beat (arrhythmia)	103 / 398	25.9%	43.3 $\pm$ 16.4
Enlarged heart	38 / 400	9.5%	42.6 $\pm$ 13.9
Heart valve problem	57 / 397	14.4%	41.2 $\pm$ 16.5
			5
Heart surgery	23 / 393	5.9%	50.7 $\pm$ 11.9
Angioplasty	4 / 23	17.4%	
Stents	8 / 23	34.8%	
Angioplasty + Stents	3 / 23	13%	
Coronary bypass	4 / 23	17.4%	
Cardiac valve surgery	4/23	17.4%	

**Table 4**

Use of antihypertensive drugs among 419 survey respondents with ADPKD

Drug	Hypertensive ADPKD Patients		Non hypertensive ADPKD Patients		All ADPKD Patients	
	N	%	N	%	N	%
Diuretics	78 / 333	23.4%	1 / 53	1.9%	79 / 387	20.4%
Sympathetic blocking agents	92 / 329	28%	2 / 54	3.7%	94 / 385	24.4%
Vasodilators	14 / 331	4.2%	1 / 53	1.9%	15 / 387	3.9%
Ca Channel blockers	87 / 330	26.4%	0 / 54	0%	87 / 386	22.5%
Angiotensin converting enzyme inhibitors	155 / 331	46.8%	6 / 54	11.1%	161 / 387	41.6%
Angiotensin receptor blockers	92 / 331	27.8%	2 / 51	3.9%	94 / 384	24.5%



**Table 5**  
Analysis of cardiovascular risk factors and events by gender among 419 survey respondents with ADPKD

Variable	Male	Female	p-value <sup>1</sup>	Adjusted p-value
Obesity (BMI ≥30)	33/140 23.6%	44/248 17.7%	0.1668	1
Current Smoker	9/60 15.0%	22/91 24.2%	0.1719	1
Diabetes	12/144 8.3%	23/264 8.7%	0.8961	1
Hypertension	127/143 88.8%	225/264 85.2%	0.3127	1
High cholesterol	68/143 47.6%	119/264 45.1%	0.6322	1
Stroke or cerebral bleeding	10/144 6.9%	20/144 7.6%	0.8154 <sup>1</sup>	1
Brain aneurysm	5/138 3.6%	14/255 5.5%	0.4101 <sup>1</sup>	1
Abdominal aortic aneurysm	2/138 1.5%	1/255 0.4%	0.2808 <sup>2</sup>	1
Angina	8/140 5.7%	5/255 2.0%	0.0726 <sup>2</sup>	1
Heart attack	16/140 11.4%	8/255 3.1%	0.0010 <sup>1</sup>	0.0136
Irregular heart beat (arrhythmia)	32/139 23.0%	71/255 27.8%	0.2980 <sup>1</sup>	1
Enlarged heart	21/140 15.0%	17/256 6.6%	0.0069 <sup>1</sup>	0.0971
Heart valve problem	17/138 12.3%	40/255 15.7%	0.3655 <sup>1</sup>	1

<sup>1</sup> Chi square test

<sup>2</sup> Fisher's exact test

ADPKD, autosomal dominant polycystic kidney disease; BMI, Body mass index;

**Table 6**  
 Analysis of cardiovascular risk factors and events by age (more or less 45 years) among 419 survey respondents with ADPKD

Variable	45 years	>45 years	p-value <sup>1</sup>	Adjusted p-value
Obesity (BMI ≥30)	17/86 19.8%	60/305 19.7%	0.9843	1
Current Smoker	11/28 39.3%	21/125 16.8%	0.0082	0.1146
Diabetes	3/91 3.3%	33/320 10.3%	0.0367	0.5140
Hypertension	59/91 64.8%	296/319 92.8%	<.0001	<.0001
High cholesterol	14/91 15.4%	174/319 54.6%	<.0001	<.0001
Stroke or cerebral bleeding	1/92 1.1%	30/319 9.4%	0.0078 <sup>2</sup>	0.1089
Brain aneurysm	2/90 2.2%	18/306 5.9%	0.1634 <sup>2</sup>	1
Abdominal aortic aneurysm	0/92 0	3/304 1.0%	n/a	1
Angina	1/92 1.1%	12/306 3.9%	0.3141 <sup>2</sup>	1
Heart attack	1/92 1.1%	23/306 7.5%	0.0231 <sup>2</sup>	0.3236
Irregular heart beat (arrhythmia)	14/91 15.4%	89/306 29.1%	0.0089 <sup>2</sup>	0.1239
Enlarged heart	2/91 2.2%	36/308 11.7%	0.0067 <sup>2</sup>	0.0943
Heart valve problem	8/91 8.8%	49/305 16.1%	0.0828 <sup>2</sup>	1

<sup>1</sup> Chi square test

<sup>2</sup> Fisher's exact test

ADPKD, autosomal dominant polycystic kidney disease; BMI, Body mass index;

**Table 7**

Analysis of cardiovascular risk factors and events by gender among 419 ADPKD survey respondents with and without ESRD.

Variable	ESRD	No ESRD	p-value <sup>1</sup>	Adjusted p-value
Obesity (BMI ≥30)	21/129 16.3%	56/257 21.8%	0.2012	1
Current Smoker	8/57 14.0%	24/94 25.5%	0.0938	1
Diabetes	22/135 16.3%	13/270 4.8%	0.0001	0.0015
Hypertension	132/135 97.8%	218/269 81.0%	<.0001	<.0001
High cholesterol	86/134 64.2%	97/270 35.9%	<.0001	<.0001
Stroke or cerebral bleeding	20/135 14.8%	10/271 6.7%	<.0001 <sup>1</sup>	0.0008
Brain aneurysm	12/131 9.2%	8/259 3.1%	0.0102 <sup>1</sup>	0.1434
Abdominal aortic aneurysm	2/131 1.5%	1/259 0.4%	0.2621 <sup>2</sup>	1
Angina	8/132 6.1%	5/260 1.9%	0.0387 <sup>2</sup>	0.5417
Heart attack	16/133 12.0%	8/259 3.1%	0.0005 <sup>1</sup>	0.0066
Irregular heart beat (arrhythmia)	44/133 33.1%	57/258 22.1%	0.0187 <sup>1</sup>	0.2614
Enlarged heart	21/132 15.9%	16/261 6.1%	0.0017 <sup>1</sup>	0.0240
Heart valve problem	23/130 17.7%	32/260 12.3%	0.1498 <sup>1</sup>	1

<sup>1</sup> Chi square test

<sup>2</sup> Fisher's exact test

ADPKD, autosomal dominant polycystic kidney disease; BMI, Body mass index;