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ORIGINAL PAPER

Patient preference for therapies in hypertension: a cross-sectional survey of German patients

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Abstract

Background Hypertension is poorly controlled in numerous patients despite effective medication being available. Catheter-based renal denervation (RDN) has emerged as an alternative treatment option. We aimed to assess how likely patients with elevated blood pressure (BP) are to accept RDN as treatment option.

Methods A questionnaire-based cross-sectional survey was performed in patients with elevated BP in Germany. Data on patient demographics, clinical characteristics and treatment preferences were collected, anonymized and analyzed.

Results One thousand and eleven patients completed the survey. Mean age was 66 years (55% male). If not already on medication ($n = 172$), 38.2% of patients would prefer RDN. Of those already on drug therapy ($n = 839$), 28.2% would opt for RDN. Patients who were pro-RDN were younger ($p < 0.0001$) and more often male ($p < 0.0001$). Nineteen percent would choose RDN if it lowered systolic BP by at least 20 mmHg, more than 40% if they did not have to take any more pills thereafter, and 30% if it would lower BP by at least 10 mmHg. Experiences of side effects and drug adherence were identified as determinants of patient preference. Physicians were the main source of information regarding medical problems (95.5%) and influence patients' decision regarding therapies (98%).

Conclusions This survey found that a significant proportion of patients would choose catheter-based RDN over lifelong pharmacotherapy. These patients were younger and more likely to be male but their expectation of the extent of BP decrease with RDN was high. Physicians are key mediators for treatment selection. They need to incorporate patient preferences into shared decision making.

Keywords Hypertension · Survey · Renal denervation · Patient choice · Preference

Introduction

Hypertension affects over 1 billion people worldwide and the number is increasing. The rate of hypertension in 1990 was 17,307 per 100,000 population, and this increased to 20,525 per 100,000 population in 2015 [1]. The complications of hypertension account for over 9 million deaths worldwide [2]. It increases the risk for stroke, myocardial infarction, heart failure, chronic kidney disease, cognitive decline, and premature death, and even small decreases in blood pressure (BP) have been shown to reduce cardiovascular (CV) events emphasizing the importance of managing this condition [3, 4].

Catheter-based renal denervation (RDN) has emerged as a treatment option for resistant hypertension in such patients [5–10]. A high level of sympathetic nerve activation has been demonstrated in untreated hypertensive patients [11]. Thus, targeting the sympathetic nervous system through

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the fibers enervating the kidneys should in theory lower BP [12]. Earlier clinical trials have shown conflicting efficacy of this procedure; however, more recent trials show promising results [7, 8, 13–16]. Vascular stiffness, but not age per se, emerged as a predictor of successful RDN [17–19]. This procedure continues to be used in Europe and Australia for patients with resistant hypertension.

The challenge in managing arterial hypertension is to choose the appropriate therapy for each individual patient. It is widely accepted that doctors and caregivers should enter into a shared decision-making process with respect to treatment decisions [20]. This will lead to better adherence of treatment and thus better health outcomes. We aimed to assess patient choice regarding treatment modalities in hypertension. More specifically, we aimed to assess how likely patients with elevated BP are to accept alternative treatment with catheter-based RDN, alone or in addition to taking antihypertensive medication.

Methods

Study design and ethics

A questionnaire-based cross-sectional survey was conducted in patients with elevated BP in primary care and cardiology offices in Germany by the *Institute for Preventative Medicine* (www.clinicaltrials.gov: NCT03548623). Patients gave their informed consent to participate, and ethical approval was obtained (*University of Erlangen-Nuremberg*).

Study population and methodology

Patients were recruited between May and September 2017 by 28 participating physicians from 8 German regions: Bayern (12), Hessen (5), Baden-Württemberg (2), Nordrhein-Westfalen (2), Sachsen (3), Sachsen-Anhalt (2), Brandenburg (1), and Niedersachsen (1). From our survey questionnaire sent to the 28 cooperating physicians, 1061 were sent back and 1011 were of good quality with respect to key questions to be entered in the database. Of the 28 cooperating physicians, 13 were specialist in general medicine and 15 in cardiology.

Patients with stage 1 or stage 2 hypertension were consecutively included in the physicians' office irrespective of the cause for their appointment. Stage 1 hypertension was defined as having a systolic blood pressure (SBP) of 140–159 mmHg or a diastolic blood pressure (DBP) of 90–99 mmHg. Stage 2 hypertension was defined as having SBP of 160–179 mmHg or DBP of 100–109 mmHg [4]. No further exclusion criteria were defined, except age had to be ≥ 18 years. Patients meeting these criteria were identified through the participating physicians and consecutively asked to complete the survey questionnaire in the waiting area in the physician's office. A one-page information sheet was also provided, describing the RDN procedure. The patient questionnaire collected information on demographics, duration of hypertension, duration of antihypertensive medication, medication (how many pills and side effects), willingness to receive alternative treatment with catheter-based RDN, and determinants for the choice of their decision. Simultaneously, participating doctors completed a medical questionnaire matching patients' information. The physician questionnaire collected information on patient demographics, duration of hypertension, duration and type of hypertension medication, comorbidities, and other medications taken by the patient. Both completed questionnaires were returned to the *Institute of Preventative Medicine* and data were anonymously entered in a database for further statistical analysis.

Statistical analyses

All data were analyzed using IBM SPSS Statistics, version 21 (IBM Corporation, Chicago, IL, USA). Frequencies and percentages were used to summarize categorical variables. Means and standard deviations (SD) were used to represent the results of continuous variables. Patients were categorized into the following categories for prespecified sub-analyses: aged < 67 years and aged ≥ 67 years; male and female gender; those with and without a history of CV disease; those on ≤ 1 AHT or ≥ 2 AHT medication; pro- and con-RDN based on their response in the questionnaire. The age 67 years was chosen as the cutoff age to define categories as this was the median age of survey respondents. In addition, for some questions we further categorized responders in 5 age groups, each of which having a reasonable sample size: age < 50 years $N = 78$, age 50–59 years $N = 188$, age 60–69 years $N = 277$, age 70–79 years $N = 317$, and age ≥ 80 years $N = 145$ (missing values $N = 6$). Demographic and clinical characteristics and treatment preferences were compared between the various grouped categories. Categorical variables were compared used the Chi squared test, while continuous variables were compared using unpaired *t* tests. A two-sided p value < 0.05 was deemed statistically significant.

Results

Demographics and clinical characteristics

A total of 1011 patients completed the survey from 8 regions of Germany: Bayern (357), Baden-Württemberg (190), Sachsen (179), Hessen (105), Nordrhein-Westfalen (54), Bremen (49), Sachsen-Anhalt (47), and Brandenburg (30).

The mean age of participants was 66 years and just over half were male (Table 1). The mean duration of hypertension

Table 1 All patients

	All ($n=1011$)
A. Demographics and clinical characteristics	
Age (years)	66.0 ± 12.2
Male gender (–)	556 (55.0%)
Duration of hypertension (years)	10.8 ± 8.7
Time on AHT medication (years)	10.2 ± 8.0
SBP (mmHg)	144.2 ± 18.9
DBP (mmHg)	84.3 ± 10.7
BMI (kg/m^2)	28.8 ± 5.2
B. Reasons survey participants would choose RDN as a treatment for high blood pressure	
Recommended by doctor	331 (34.5%)
If it reliably lowers blood pressure	304 (31.7%)
If certain it will be effective	295 (30.8%)
If costs are paid for by health insurance	287 (29.9%)
If I need to take fewer tablets as a result	212 (22.1%)
If it is one-time medical procedure and not an additional tablet	196 (20.4%)
If I get closer to ideal SBP of 120 mm Hg	137 (14.3%)
If recommended by someone who has already been treated with it	135 (14.1%)
If blood pressure fluctuates less after	117 (12.2%)
If I will tolerate it better than tablets	86 (9.0%)
I am not interested in treatment with catheter-based RDN	386 (40.2%)

AHT antihypertensive, *BMI* body mass index, *DBP* diastolic blood pressure, *RDN* renal denervation, *SBP* systolic blood pressure

and time on AHT medication was 10.8 and 10.2 years, respectively. The most common medication taken for hypertension were beta blockers ($n=575$, 56.9%), followed by angiotensin-converting enzyme (ACE) inhibitors ($n=425$, 42%) and angiotensin receptor blockers ($n=421$, 41.6%). One-third of patients were treated with diuretics ($n=342$, 33.8%) and/or calcium antagonists ($n=330$, 32.6%). The least common medications were mineralocorticoid receptor (MR) antagonists ($n=42$, 4.2%), alpha blockers ($n=39$, 3.9%), and/or vasodilators ($n=14$, 1.4%).

Patients aged ≥ 67 years had a longer duration of hypertension ($p<0.005$) and longer time on AHT medication ($p<0.005$) than those aged < 67 years (Table 2). Patients < 67 years had a higher diastolic BP (DBP) ($p<0.005$) and body mass index (BMI) ($p<0.005$) than those aged ≥ 67 years. Female patients had higher systolic BP (SBP) ($p=0.05$) and DBP ($p=0.02$) than males. Patients with a history of CV disease were older ($p<0.005$), had a longer duration of hypertension ($p=0.01$) and time on AHT medication ($p<0.005$), and were more likely to be male ($p<0.005$) than those with no history of CV disease (Table 3). The latter group had a higher DBP ($p<0.005$) than patients with a history of CV disease. Patients on two or more AHT drugs were older ($p<0.005$), had a longer duration of hypertension ($p<0.005$) and longer time on AHT medication ($p<0.005$), and a higher BMI ($p=0.002$) than those on none or only one AHT drug. The latter group had a higher DBP ($p<0.005$) than patients on two or more AHT drugs.

Treatment preference

If not on medication for high BP ($n=172$), 61.7% ($n=106$) of survey participants would prefer tablets and 38.2% ($n=66$) would opt for one-time catheter-based RDN (Fig. 1a). When we categorized our patients according to five age groups, the percentage of patients that would opt for one-time catheter-based RDN was similar with increasing age: the percentages were in the age groups < 50 years 39%, 50–59 years 39.4%, 60–69 years 36.9%, 70–79 years 36.7% and ≥ 80 years 36.3%. Among those patients on antihypertensive medication, when asked which additional treatment they would choose if their blood pressure remained high despite being on medication, 71.8% would rather take an additional tablet for the high BP and 28.2% would opt for one-time catheter-based RDN (Fig. 1b). When categorized according to the age groups, the percentage of patients that would opt for one-time catheter-based RDN decreased with aging: the percentages were in the age group < 50 years 44.0%, 50–59 years 31.3%, 60.69 years 34.5% 70–70 years 21.5% and ≥ 80 years 17.0%.

Patients were asked a range of questions to depict what catheter-based RDN would have to achieve for them to opt for this treatment (Fig. 2). Over 40% would not be

Table 2 Patients by age group and gender

	< 67 years ($n = 471$)	≥ 67 years ($n = 530$)	p value	Male ($n = 556$)	Female ($n = 445$)	p value
A. Demographics and clinical characteristics						
Age (years)	–	–	–	65.6 ± 12.4	66.5 ± 12.0	0.283
Male gender	268 (56.9%)	288 (54.3%)	0.416	–	–	–
Duration of hypertension (years)	9.0 ± 8.0	12.4 ± 9.0	< 0.005	11.2 ± 9.0	10.3 ± 8.3	0.079
Time on AHT medication (years)	8.3 ± 7.1	11.8 ± 8.2	< 0.005	10.5 ± 8.1	9.7 ± 7.7	0.120
SBP (mmHg)	144 ± 18	145 ± 19	0.309	143 ± 19	146 ± 19	0.050
DBP (mmHg)	87 ± 10	82 ± 10	< 0.005	84 ± 11	85 ± 10	0.022
BMI (kg/m^2)	30 ± 5.9	28 ± 4.4	< 0.005	29 ± 4.5	29 ± 6.0	0.637
B. Preference for tablet or catheter-based RDN						
If not yet taking HBP medication, would prefer:			< 0.001			0.283
Tablets	58 (65.2%)	31 (34.8%)		43 (48.9%)	45 (51.1%)	
Catheter-based RDN	35 (63.6%)	20 (36.4%)		30 (54.5%)	25 (45.5%)	
If on AHT medication but blood pressure still too high, would prefer:			< 0.001			0.015
Tablets	289 (44.9%)	355 (55.1%)		344 (53.5%)	299 (46.5%)	
Catheter-based RDN	154 (60.4%)	101 (39.6%)		158 (62.5%)	95 (37.5%)	
C. Participants would choose RDN as a treatment for high blood pressure						
Recommended by doctor	178 (38.7%)	153 (30.7%)	0.010	209 (39.1%)	120 (28.7%)	0.001
If it reliably lowers blood pressure	192 (41.7%)	111 (22.3%)	< 0.001	193 (36.1%)	109 (25.8%)	0.001
If certain it will be effective	168 (36.6%)	126 (25.3%)	< 0.001	172 (32.3%)	122 (28.9%)	0.264
If costs are paid for by health insurance	164 (35.7%)	122 (24.5%)	< 0.001	159 (29.8%)	128 (30.3%)	0.852
If I need to take fewer tablets as a result	125 (27.2%)	87 (17.5%)	< 0.001	133 (24.9%)	77 (18.2%)	0.014
If it is one-time medical procedure and not an additional tablet	112 (24.3%)	84 (16.9%)	0.004	117 (21.9%)	78 (18.5%)	0.192
If I get closer to ideal SBP of 120 mmHg	91 (19.8%)	46 (9.2%)	< 0.001	92 (17.2%)	43 (10.2%)	0.002
If recommended by someone who has already been treated with it	85 (18.5%)	50 (10%)	< 0.001	78 (14.6%)	56 (13.3%)	0.554
If blood pressure fluctuates less after	64 (13.9%)	53 (10.6%)	0.119	58 (10.9%)	57 (13.5%)	0.216
If I will tolerate it better than tablets	45 (9.8%)	41 (8.2%)	0.402	53 (9.9%)	32 (7.6%)	0.206
I am not interested in treatment with catheter-based RDN	132 (28.7%)	253 (50.8%)	< 0.001	193 (36.1%)	192 (45.5%)	0.003

Data are given as mean ± SD or n (%)

AHT antihypertensive, *BMI* body mass index, *HBP* high blood pressure, *RDN* renal denervation, *SBP* systolic blood pressure

treated with this procedure in any case. Nineteen percent would choose catheter-based RDN if it lowered their SBP by ≥ 20 mmHg. Over 40% of respondents would prefer the procedure if they did not have to take any more pills for high BP after. Thirty percent would choose catheter-based RDN if they were 100% sure it would lower their BP by at least 10 mmHg.

Patients were asked why they would choose RDN as a treatment for high BP (Table 1b). The most likely reasons were if RDN was recommended by the doctor (34.5%), when it reliably lowers BP (31.7%), and if they could be sure that it is effective (30.8%). Recommendation by their doctor was the most important reason in patients aged ≥ 67 years (30.7%), males (39.1%), patients with a history of CV disease (35.5%), and those on two or more AHT drugs (36.2%) to prefer catheter-based RDN (Tables 2b, 3b). Reliably lowering BP was the main reason in patients aged < 67 years (41.7%), those with no history of CV disease (35.4%), and those on none or only one AHT drug (31.0%) to choose to be treated with catheter-based RDN.

The majority of patients reported that doctors were most likely to be their main source of information regarding medical problems (95.5%) and to influence their decision regarding medical therapies (98.0%; Fig. 3a, b). Partners were second most likely to influence patients' decision regarding their therapies. By and large, this was true for all subgroups of patients of interest. In addition to the prominent role of the physician, older subjects (> 67 years) reported the pharmacist as second source (age > 67 years: 25.3% vs age < 67 years 4.8%) and younger patients the

Table 3 Patients by prior cardiovascular event and antihypertensive treatment

	CV yes ($n=537$)	CV no ($n=379$)	p value	AHT ≤ 1 ($n=288$)	AHT ≥ 2 ($n=702$)	p value
A. Demographics and clinical characteristics						
Age (years)	70.0 ± 9.9	62.2 ± 12.7	< 0.005	61.6 ± 13.3	67.9 ± 11.3	< 0.005
Male gender (–)	334 (62.8%)	184 (48.9%)	< 0.005	148 (51.7%)	399 (57.3%)	0.110
Duration of hypertension (years)	11.7 ± 8.5	10.2 ± 8.7	0.010	7.6 ± 7.3	12.3 ± 8.9	< 0.005
Time on AHT medication (years)	11.4 ± 8.2	9.2 ± 7.4	< 0.005	7.0 ± 6.7	11.6 ± 8.1	< 0.005
SBP (mmHg)	143 ± 19	145 ± 19	0.152	145 ± 18	144 ± 19	0.248
DBP (mmHg)	82 ± 10	87 ± 10	< 0.005	86 ± 111	83 ± 10	< 0.005
BMI (kg/m^2)	29.1 ± 4.9	28.6 ± 5.6	0.228	28.0 ± 5.2	29.2 ± 5.2	0.002
B. Preference for tablet or catheter-based RDN						
If not yet taking HBP medication, would prefer:			0.004		< 0.005	
Tablets	33 (42.9%)	44 (157.1%)		39 (48.1%)	42 (51.9%)	
Catheter-based RDN	26 54.2%)	22 (45.8%)		25 (48.1%)	27 (51.9%)	
If on AHT medication but blood pressure still too high, would prefer:			0.061		0.658	
Tablets	330 (56.0%)	259 (44.0%)		186 (29.3%)	449 (70.7%)	
Catheter-based RDN	146 (63.2%)	85 (36.8%)		77 (30.8%)	173 (69.2%)	
C. Participants would choose RDN as a treatment for high blood pressure						
Recommended by doctor	179 (35.5%)	118 (32.4%)	0.342	80 (29.5%)	242 (36.2%)	0.052
If it reliably lowers blood pressure	147 (29.2%)	129 (35.4%)	0.050	84 (31.0%)	214 (32.0%)	0.767
If certain it will be effective	150 (29.8%)	116 (32.0%)	0.490	81 (30.0%)	208 (31.1%)	0.743
If costs are paid for by health insurance	153 (30.4%)	104 (28.6%)	0.570	77 (28.4%)	206 (30.8%)	0.471
If I need to take fewer tablets as a result	122 (24.2%)	73 (20.1%)	0.148	56 (20.7%)	152 (22.7%)	0.491
If it is one-time medical procedure and not an additional tablet	105 (20.8%)	72 (19.8%)	0.704	58 (21.4%)	132 (19.7%)	0.563
If I get closer to ideal SBP of 120 mm Hg	60 (11.9%)	61 (16.8%)	0.042	36 (13.3%)	97 (14.5%)	0.628
If recommended by someone who has already been treated with it	64 (12.7%)	59 (16.2%)	0.143	36 (13.3%)	95 (14.2%)	0.713
If blood pressure fluctuates less after	63 (12.5%)	44 (12.1%)	0.867	31 (11.5%)	82 (12.3%)	0.741
If I will tolerate it better than tablets	52 (10.3%)	24 (6.6%)	0.055	27 (10%)	59 (8.8%)	0.581
I am not interested in treatment with catheter-based RDN	217 (43.1%)	136 (37.4%)	0.092	110 (40.6%)	269 (40.2%)	0.914

Data are given as *n* (%)

AHT antihypertensive, *BMI* body mass index, *CV* cardiovascular, *DBP* diastolic blood pressure, *SBP* systolic blood pressure, *SD* standard deviation, *HBP* high blood pressure, *RDN* renal denervation

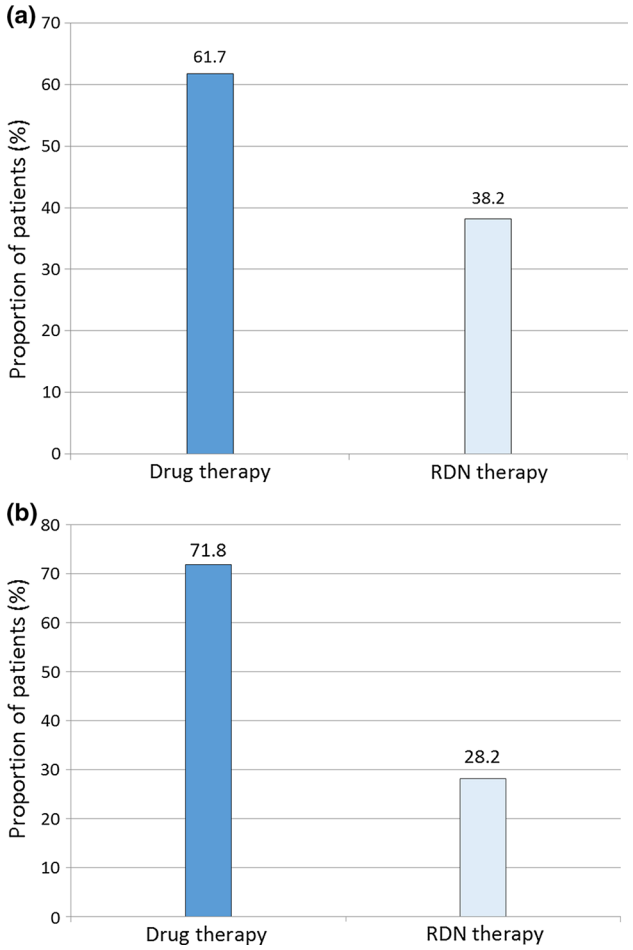

Fig. 1 **a** Patients preference for drug therapy versus invasive catheter-based RDN. Patients free of any antihypertensive medication ($N=172$, 17% of all subjects). **b** Patients preference for drug therapy versus invasive catheter-based RDN. Patients on ≥ 1 antihypertensive drug medication ($N=839$, 83% of all subjects)

world wide web as second choice (age > 67 years: 12.4% vs. age < 67 years: 23.4%) for getting information about medical problems.

Side effects

A comparison of side effects from AHT medication between patient groups with a preference for RDN versus those having a preference for tablets is displayed in Table 4. Only 47.8% of patients who preferred treatment with RDN had never experienced side effects compared to roughly 63.7% of patients with a preference for tablets ($p<0.001$). In 23.7% of patients with a preference for RDN, medication had to be changed due to side effects, as opposed to 17% in the group with a preference for tablets ($p=0.02$). In the patient group who preferred RDN, tiredness/weakness (12.9%) was the most common side effect, followed by cough (9.5%). The most likely side effects experienced in patients who preferred tablets was cough (9.1%) followed by tiredness/weakness (7.7%).

Adherence

Almost 87% of patients with a preference for tablets reported that they were always adherent to their AHT pills compared to only 77% of patients with a preference for RDN ($p=0.007$, Table 4). The most common reported reason for non-adherence in both groups was forgetting to take their medication. A higher proportion of patients with a preference for RDN compared to tablets were averse to side effects, afraid of being harmed by drugs in the long term and did not want to be dependent on medication.

Comparison of participants who were pro- versus con-RDN

Of 883 participants, who answered this part of the questionnaire in good quality, 520 (58.9%) were open to be treated with RDN ('pro-RDN') and 363 (41.1%) were against RDN ('con-RDN'). There were significant differences between these patient groups (Table 5). Patients who were 'con-RDN' were older ($p<0.0001$) and more likely to be female ($p<0.0001$). A higher proportion of 'con-RDN' participants had an office DBP < 90 ($p=0.003$) and an estimated glomerular filtration rate (eGFR) < 60 ml/min/1.73 m^2 ($p=0.001$). Patients who were 'pro-RDN' had a higher diastolic office BP ($p=0.04$) and were on more antihypertensive drugs ($p=0.03$).

Discussion

This study reports on patient preference regarding treatment in hypertension, in particular how likely patients with elevated BP are prone to accept alternative treatment with catheter-based RDN. We found that almost 40% of hypertensive survey participants not on medication would rather choose one-time catheter-based RDN than drug therapy and almost 30% of those on drug therapy would opt for RDN. Expectations of BP decrease from RDN were high. More males and younger patients preferred one-time catheter-based RDN, and the doctor is the key mediator regarding which treatment option is chosen.

It is a known fact that males are more likely to take risk than females [21]. As RDN is an invasive procedure and thus perceived to be riskier than taking tablets, it is perhaps not surprising that more males than females were likely to choose catheter-based RDN in our study. Younger patients were also more likely to choose RDN. Again, this is perhaps not surprising as younger patients have many years of potential drug administration ahead of them. Hutchins et al. [22]

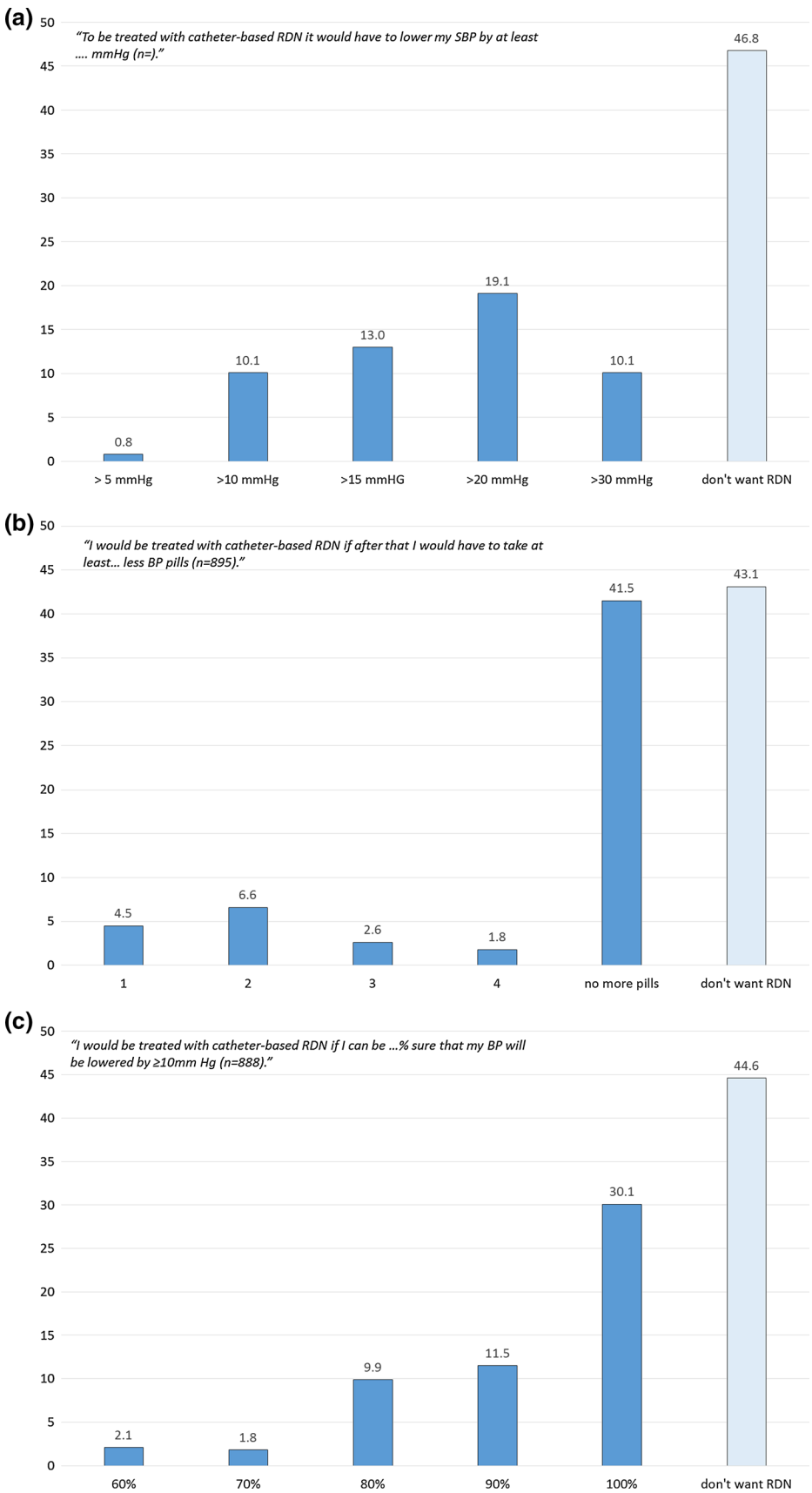

Fig. 2 Patient expectations to choose catheter-based RDN as treatment

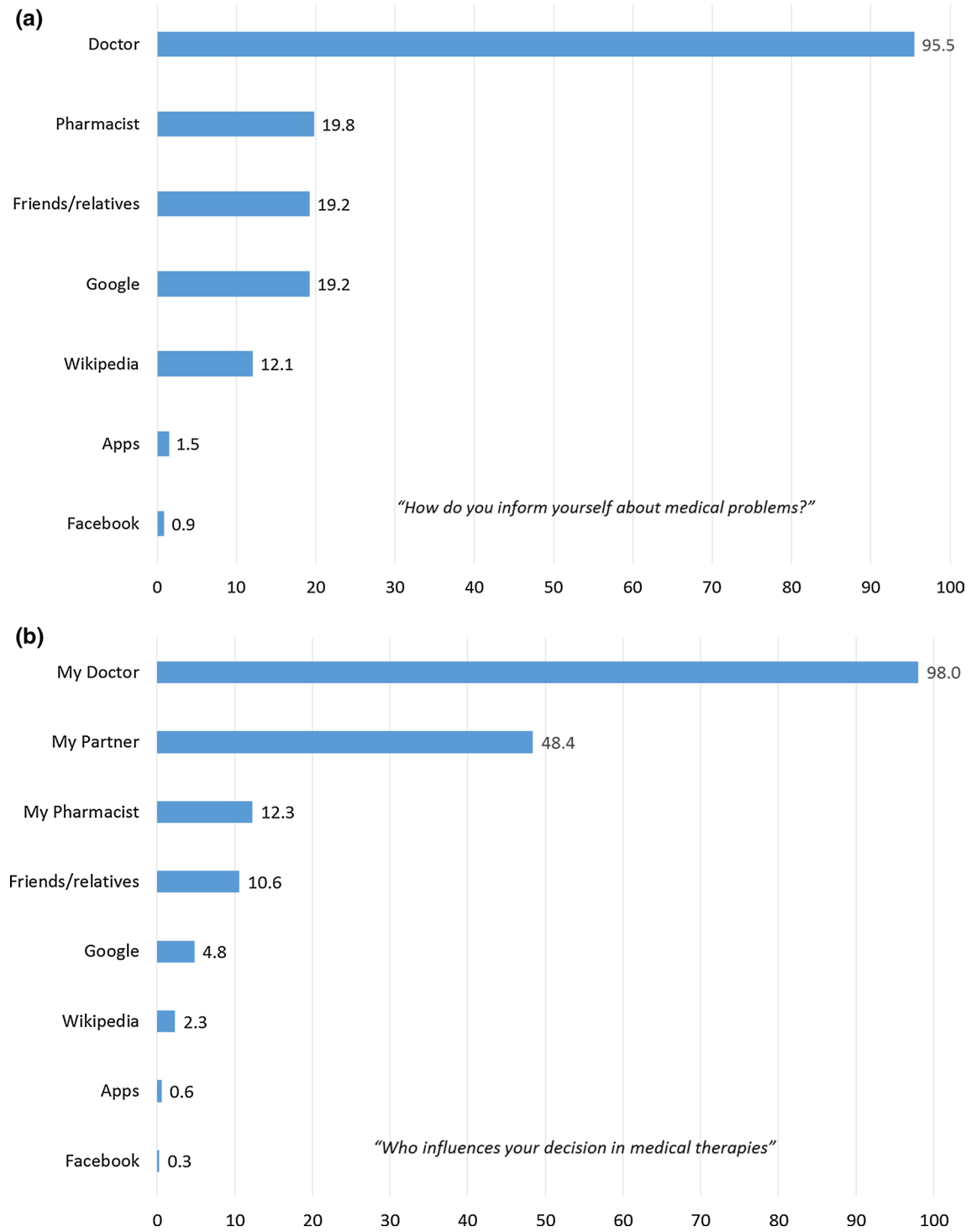

Fig. 3 **a** Source of information about medical problems. **b** Source of information for patients' decision

reported as many as 30% of 1000 patients from a US-based survey would prefer dying earlier than taking more drugs for CV prevention.

The use of RDN in the treatment of hypertension is controversially discussed in the medical community. After initial promising clinical trial results, the SIMPLICITY HTN-3 trial threw a spanner in the works and showed no statistically significant difference in BP reduction between RDN and control group [23]. Potential shortcomings of the trial were implicated in terms of trial design, operator

Table 4 Side effects from and adherence to AHT medication in patient groups with a preference for tablets versus RDN

	Preference for tablets ($n=625$)	Preference for RDN ($n=253$)
Have you had side effects with AHT medication?		
Yes, and still have them	35 (5.6%)	20 (7.9%)
Yes, but went away after some time	39 (6.2%)	21 (8.3%)
Yes, and talked to doctor about it	88 (14.1%)	51 (20.2%)
Doctor prescribed other tablets because of side effects	106 (17.0%)	60 (23.7%)
Yes, and stopped taking tablets without talking to doctor	6 (1.0%)	3 (1.2%)
Never had side effects with HBP tablets	398 (63.7%)	121 (47.8%)
Never taken HBP tablets	32 (5.1%)	15 (5.9%)
Which side effects have you experienced if stopped taking AHT medication due to them?		
Headache	24 (4.5%)	6 (2.9%)
Tiredness/weakness	41 (7.7%)	27 (12.9%)
Frequent urination	22 (4.1%)	16 (7.6%)
Confusion/difficulty thinking	6 (1.1%)	6 (2.9%)
Dry mouth	22 (4.1%)	11 (5.2%)
Impaired sexual activity	9 (1.7%)	16 (7.6%)
Constant cough	48 (9.1%)	20 (9.5%)
Others	30 (5.6%)	19 (9.0%)
No side effects so severe that stopped taking tablets	368 (69.3%)	120 (57.1%)
No HBP tablets prescribed	22 (4.1%)	15 (7.1%)
Adherence to AHT tablets		
Always	549 (86.5%)	194 (77.0%)
Not always	63 (10.0%)	40 (15.9%)
Reasons for non-adherence to AHT tablets		
Do not want side effects	8 (1.5%)	7 (3.3%)
Afraid of being harmed by drugs long term	6 (1.1%)	10 (4.7%)
Do not want to be dependent on medication	6 (1.1%)	8 (3.8%)
Forgot to take medication	61 (11.4%)	35 (16.6%)
Forgot to get prescription for medication	3 (0.6%)	8 (3.8%)
Always take medicine as prescribed	407 (75.9%)	141 (66.8%)

Data are given as *n* (%)

AHT antihypertensive, *RDN* renal denervation

inexperience, inadequate ablation procedure and patient characteristics (e.g., patients with isolated systolic hypertension respond less to RDN) [24]. However, early results of the three recently published double-blind, randomized, sham-controlled trials (SPYRAL HTN-OFF MED, ON MED and RADIANCE-HTN SOLO) have shown significant and clinically meaningful reduction of BP with RDN treatment to sham procedure [13–16]. This has put RDN back on the agenda for the treatment of high BP. Our survey investigated patient's preference of AHT treatment and the proportion of patients in this study who would choose RDN as their preferred treatment, is substantial. It is also worth noting that 40% of patients in our study were consistently against RDN. More pivotal trials are currently conducted and the results will guide and enable patients and physicians to allow evidence-based decisions. In this process, it is increasingly important to incorporate patient choice into treatment decisions, since increased patient involvement is associated with improved health outcomes [25, 26]. A study showed that patient choice was associated with improved decision quality, a greater knowledge of treatment options, and an increased rate of selecting the option that matches the patients' values. Patient choice was not associated with increased anxiety or depression, or worse health outcomes [26].

Strengths and limitations

The main strengths of this study were the large sample size and the fact that survey participants came from several German regions ensuring sample representativeness. Patients were recruited in primary care and cardiology offices and those with the diagnosis hypertension were consecutively enrolled if they were willing to participate. On the other

Table 5 Comparison of demographic and clinical characteristics between pro-RDN and con-RDN participants

	Pro-RDN ($n=520$)	Con-RDN ($n=363$)	p value
Age (years)	63 ± 12	69 ± 12	**< 0.001**
Male gender (–)	318 (61.2%)	177 (48.8%)	**< 0.001**
Mean BMI (kg/m^2)	29.2 ± 5.4	28.7 ± 5.3	0.194
SBP (mmHg)	144 ± 19	146 ± 19	0.171
DBP (mmHg)	85 ± 10	83 ± 11	**0.043**
Duration of hypertension (years)	10.7 ± 8.8	10.7 ± 8.4	0.945
Time on AHT drugs (years)	4.7 ± 1.5	4.9 ± 1.3	0.067
No. hypertensive drugs	2.0 ± 1.2	1.8 ± 1.1	**0.031**
No. total drug intake	4.1 ± 2.1	4.1 ± 2.1	0.16
Office SBP < 140 mmHg	186 (35.7%)	116 (32%)	0.665
Office SBP ≥ 140 mmHg	334 (64.3%)	247 (68%)	0.288
Office DBP < 90 mmHg	329 (63.3%)	238 (65.5%)	**0.003**
Office DBP ≥ 90 mmHg	191 (36.7%)	125 (34.5%)	0.710
CV disease	292 (56.2%)	221 (60.9%)	0.181
eGFR < 60 ml/min/1.73 m^2	26 (5.1%)	41 (11.4%)	**0.001**
Hyperlipidaemia	258 (49.7%)	172 (47.3%)	0.521
Antidiabetics	118 (22.7%)	76 (20.9%)	0.597
Statin	264 (50.8%)	172 (47.4%)	0.381
Patient's information by doctor	496 (95.3%)	349 (96.1%)	0.617
Patient's decision influence by doctor	512 (98.4%)	352 (97.1%)	0.234

Data are given as mean ± SD or n (%)

$p < 0.05$ are indicated in bold

AHT antihypertensive, *BMI* body mass index, *BP* blood pressure, *CV* cardiovascular, *DBP* diastolic blood pressure, *eGFR* estimated glomerular filtration rate, *RDN* renal denervation, *SBP* systolic blood pressure

hand, some limitations were also evident. First, this study was restricted to Germany and thus views of patients here may not represent those of populations from other countries, cultures, and religions. Second, we do not know how many of the patients asked to participate did so. Third, the survey questionnaire methodology relies on self-reporting by patients and only clinical data were provided by the physician. No structured or semi-structured interview took place that may have further provided insights into determinants of patient preference. We did not aim to analyze the hurdles educational tools that physicians need to enter a structured process of shared decision making with the patient. This needs to be evaluated in future research activities.

Conclusions and clinical implications

In conclusion, this study of patient preferences in AHT treatment found that almost 40% of those patients not on medication and almost 30% of those on drug therapy were prone to choose one-time catheter-based RDN in the treatment of hypertension. Patients who chose this option were more likely to be younger and male, and their expectation of BP decrease with the procedure was high. The doctor is the key mediator regarding which treatment option is chosen by the patient. These data demand that patient preference needs to be incorporated in a shared process of treatment decisions.

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Compliance with ethical standards

Conflict of interest RES received Speaker fees, Consultancy and Advisory Board fees from Ablative Solutions, Medtronic, Recor and ROX Medical. Research grant to the institution has been given to RES by Ablative Solutions, Medtronic, Recor and ROX Medical. RV received a research grant to the institution from Medtronic. All the other authors have no competing financial interests to declare.

Ethical approval Ethical approval was obtained (University of Erlangen-Nuremberg, Germany).

References

1. Forouzanfar MH, Liu P, Roth GA, Ng M, Biryukov S, Marczak L, Alexander L, Estep K, Hassen Abate K, Akinyemiju TF, Ali R, Alvis-Guzman N, Azzopardi P, Banerjee A, Barnighausen T, Basu A, Bekele T, Bennett DA, Biadgilign S, Catala-Lopez F, Feigin VL,

Fernandes JC, Fischer F, Gebru AA, Gona P, Gupta R, Hankey GJ, Jonas JB, Judd SE, Khang YH, Khosravi A, Kim YJ, Kimokoti RW, Kokubo Y, Kolte D, Lopez A, Lotufo PA, Malekzadeh R, Melaku YA, Mensah GA, Misganaw A, Mokdad AH, Moran AE, Nawaz H, Neal B, Ngalesoni FN, Ohkubo T, Pourmalek F, Rafay A, Rai RK, Rojas-Rueda D, Sampson UK, Santos IS, Sawhney M, Schutte AE, Sepanlou SG, Shifa GT, Shiue I, Tedla BA, Thrift AG, Tonelli M, Truelsen T, Tsilimparis N, Ukwaja KN, Uthman OA, Vasankari T, Venketasubramanian N, Vlassov VV, Vos T, Westerman R, Yan LL, Yano Y, Yonemoto N, Zaki ME, Murray CJ (2017) Global burden of hypertension and systolic blood pressure of at least 110 to 115 mm Hg, 1990–2015. JAMA 317:165–182

2. Collaborators, GBDRF (2017) Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 390:1345–1422
3. Ettehad D, Emdin CA, Kiran A, Anderson SG, Callender T, Emberson J, Chalmers J, Rodgers A, Rahimi K (2016) Blood pressure lowering for prevention of cardiovascular disease and death: a systematic review and meta-analysis. Lancet 387:957–967
4. Williams B, Mancia G, Spiering W, Agabiti Rosei E, Azizi M, Burnier M, Clement DL, Coca A, de Simone G, Dominiczak A, Kahan T, Mahfoud F, Redon J, Ruilope L, Zanchetti A, Kerins M, Kjeldsen SE, Kreutz R, Laurent S, Lip GYH, McManus R, Narkiewicz K, Ruschitzka F, Schmieder RE, Shlyakhto E, Tsioufis C, Aboyans V, Desormais I, Authors/Task Force, M (2018) ESC/ESH guidelines for the management of arterial hypertension: the Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension: The Task Force for the management of arterial hypertension of the European Society of Cardiology and the European Society of Hypertension. J Hypertens 2018(36):1953–2041
5. Mahfoud F, Schmieder RE, Azizi M, Pathak A, Sievert H, Tsioufis C, Zeller T, Bertog S, Blankestijn PJ, Bohm M, Burnier M, Chatellier G, Durand Zaleski I, Ewen S, Grassi G, Joner M, Kjeldsen SE, Lobo MD, Lotan C, Luscher TF, Parati G, Rossignol P, Ruilope L, Sharif F, van Leeuwen E, Volpe M, Windecker S, Witkowski A, Wijns W (2017) Proceedings from the 2nd European Clinical Consensus Conference for device-based therapies for hypertension: state of the art and considerations for the future. Eur Heart J 38:3272–3281
6. Donazzan L, Mahfoud F, Ewen S, Ukena C, Cremers B, Kirsch CM, Hellwig D, Eweiwi T, Ezziddin S, Esler M, Bohm M (2016) Effects of catheter-based renal denervation on cardiac sympathetic activity and innervation in patients with resistant hypertension. Clin Res Cardiol 105:364–371
7. Tsioufis C, Ziakas A, Dimitriadis K, Davlouros P, Marketou M, Kasiakogias A, Thomopoulos C, Petroglou D, Tsiachris D, Doumas M, Skalidis E, Karvounis C, Alexopoulos D, Vardas P, Kallikazaros I, Stefanadis C, Papademetriou V, Tousoulis D (2017) Blood pressure response to catheter-based renal sympathetic denervation in severe resistant hypertension: data from the Greek Renal Denervation Registry. Clin Res Cardiol 106:322–330
8. Ott C, Kopp C, Dahlmann A, Schmid A, Linz P, Cavallaro A, Hammon M, Ditting T, Veelken R, Uder M, Titze J, Schmieder RE (2018) Impact of renal denervation on tissue Na(+) content in treatment-resistant hypertension. Clin Res Cardiol 107:42–48
9. Kulenthiran S, Ewen S, Bohm M, Mahfoud F (2017) Hypertension up to date: SPRINT to SPYRAL. Clin Res Cardiol 106:475–484
10. Oparil S, Schmieder RE (2015) New approaches in the treatment of hypertension. Circ Res 116:1074–1095
11. Schlaich M, Hering D, Lambert G, Eikelis N, Philipps S, Lambert E, Sata Y, Esler M (2017) [PP.05.32] Profound sympathetic nervous system activation in patients with resistant hypertension. J Hypertens 35:e127
12. Hoogerwaard AF, de Jong MR, Adiyaman A, Smit JJJ, Delnoy P, Heeg JE, van Hasselt B, Ramdat Misier AR, Rienstra M, van Gelder IC, Elvan A (2019) Renal sympathetic denervation induces changes in heart rate variability and is associated with a lower sympathetic tone. Clin Res Cardiol 108:22–30
13. Schmieder RE, Mahfoud F, Azizi M, Pathak A, Dimitriadis K, Kroon AA, Ott C, Scalise F, Mancia G, Tsioufis C, Members of the ESHWGoITo H (2018) European Society of Hypertension position paper on renal denervation 2018. J Hypertens 36:2042–2048
14. Azizi M, Schmieder RE, Mahfoud F, Weber MA, Daemen J, Davies J, Basile J, Kirtane AJ, Wang Y, Lobo MD, Saxena M, Feyz L, Rader F, Lurz P, Sayer J, Sapoval M, Levy T, Sanghvi K, Abraham J, Sharp ASP, Fisher NDL, Bloch MJ, Reeve-Stoffer H, Coleman L, Mullin C, Mauri L, Investigators R-H (2018) Endovascular ultrasound renal denervation to treat hypertension (RADIANCE-HTN SOLO): a multicentre, international, single-blind, randomised, sham-controlled trial. Lancet 391:2335–2345
15. Kandzari DE, Bohm M, Mahfoud F, Townsend RR, Weber MA, Pocock S, Tsioufis K, Tousoulis D, Choi JW, East C, Brar S, Cohen SA, Fahy M, Pilcher G, Kario K, Investigators, SH-OMT (2018) Effect of renal denervation on blood pressure in the presence of antihypertensive drugs: 6-month efficacy and safety results from the SPYRAL HTN-ON MED proof-of-concept randomised trial. Lancet 391:2346–2355
16. Townsend RR, Mahfoud F, Kandzari DE, Kario K, Pocock S, Weber MA, Ewen S, Tsioufis K, Tousoulis D, Sharp ASP, Watkinson AF, Schmieder RE, Schmid A, Choi JW, East C, Walton A, Hopper I, Cohen DL, Wilensky R, Lee DP, Ma A, Devireddy CM, Lea JP, Lurz PC, Fengler K, Davies J, Chapman N, Cohen SA, DeBruin V, Fahy M, Jones DE, Rothman M, Bohm M, investigators*, SH-OMt (2017) Catheter-based renal denervation in patients with uncontrolled hypertension in the absence of antihypertensive medications (SPYRAL HTN-OFF MED): a randomised, sham-controlled, proof-of-concept trial. Lancet 390:2160–2170
17. Fengler K, Rommel KP, Blazek S, Von Roeder M, Besler C, Lucke C, Gutberlet M, Steeden J, Quail M, Desch S, Thiele H, Muthurangu V, Lurz P (2018) Cardiac magnetic resonance assessment of central and peripheral vascular function in patients undergoing renal sympathetic denervation as predictor for blood pressure response. Clin Res Cardiol 107:945–955
18. Steinmetz M, Nelles D, Weisser-Thomas J, Schaefer C, Nickenig G, Werner N (2018) Flow-mediated dilation, nitroglycerin-mediated dilation and their ratio predict successful renal denervation in mild resistant hypertension. Clin Res Cardiol 107:611–615
19. Stoiber L, Mahfoud F, Zamani SM, Lapinskas T, Bohm M, Ewen S, Kulenthiran S, Schlaich MP, Esler MD, Hammer T, Stensaeth KH, Pieske B, Dreysse S, Fleck E, Kuhne T, Kelm M, Stawowy P, Kelle S (2018) Renal sympathetic denervation restores aortic distensibility in patients with resistant hypertension: data from a multi-center trial. Clin Res Cardiol 107:642–652
20. Hess EP, Coylewright M, Frosch DL, Shah ND (2014) Implementation of shared decision making in cardiovascular care: past, present, and future. Circ Cardiovasc Qual Outcomes. 7:797–803
21. Baker P, Shand T (2017) Men's health: time for a new approach to policy and practice? J Glob Health. 7:010306
22. Hutchins R, Viera AJ, Sheridan SL, Pignone MP (2015) Quantifying the utility of taking pills for cardiovascular prevention. Circ Cardiovasc Qual Outcomes 8:155–163
23. Bhatt DL, Kandzari DE, O'Neill WW, D'Agostino R, Flack JM, Katzen BT, Leon MB, Liu M, Mauri L, Negoita M, Cohen SA, Oparil S, Rocha-Singh K, Townsend RR, Bakris GL, Investigators, SH (2014) A controlled trial of renal denervation for resistant hypertension. N Engl J Med. 370:1393–1401
24. Kandzari DE, Bhatt DL, Brar S, Devireddy CM, Esler M, Fahy M, Flack JM, Katzen BT, Lea J, Lee DP, Leon MB, Ma A, Massaro J, Mauri L, Oparil S, O'Neill WW, Patel MR, Rocha-Singh K, Sobotka

PA, Svetkey L, Townsend RR, Bakris GL (2015) Predictors of blood pressure response in the SYMPLICITY HTN-3 trial. Eur Heart J 36:219–227

25. Say RE, Thomson R (2003) The importance of patient preferences in treatment decisions–challenges for doctors. BMJ 327:542–545
26. Stacey D, Legare F, Lewis KB (2017) Patient decision aids to engage adults in treatment or screening decisions. JAMA 318:657–658