

Supplementary Material

Patients With Atrial Fibrillation Benefit From SAVR With Surgical Ablation Compared To TAVR Alone

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Supplementary Material Table 1 – Unmatched baseline characteristics of sample population

Characteristic	TAVR (n = 1,494)	SAVR-SA (n = 2,591)	Total (n = 4,085)	SMD or p-value
Age - mean (SD)	83.6 (6.8)	75.7 (6.3)	78.6 (7.5)	1.22
Male - n (%)	776 (51.9)	1794 (69.3)	2570 (62.9)	0.36
Race - n (%)				0.02
Unknown	3 (0.2)	27 (1.0)	30 (0.7)	
White	1444 (96.7)	2488 (96.0)	3932 (96.3)	
Black	21 (1.4)	28 (1.1)	49 (1.2)	
Other	5 (0.3)	20 (0.8)	25 (0.6)	
Asian	10 (0.7)	10 (0.4)	20 (0.5)	
Hispanic	8 (0.5)	15 (0.6)	23 (0.6)	
Native American	3 (0.2)	3 (0.1)	6 (0.2)	
Year - n (%)				<0.01
2012	84 (5.6)	499 (19.3)	583 (14.3)	
2013	133 (8.9)	534 (20.6)	667 (16.3)	
2014	211 (14.0)	611 (23.6)	822 (20.1)	
2015	243 (16.3)	444 (17.1)	687 (16.8)	
2016	235 (15.7)	207 (8.0)	442 (10.8)	
2017	282 (18.9)	141 (5.4)	423 (10.4)	

2018	306 (20.5)	155 (6.0)	461 (11.3)	
Preoperative comorbidities - mean (SD)				
CHA2DS2-VASC Score	3.7 (0.9)	3.0 (1.0)	3.2 (1.0)	0.71
HAS-BLED Score	1.9 (0.4)	1.8 (0.5)	1.9 (0.5)	0.16
Elixhauser comorbidities - n (%)				
Blood loss anemia	14 (0.9)	21 (0.8)	35 (0.9)	0.01
Coagulopathy	115 (7.7)	232 (9.0)	347 (8.5)	-0.05
Chronic pulmonary disease	103 (6.9)	233 (9.0)	336 (8.2)	-0.08
Depression	105 (7.0)	182 (7.0)	287 (7.0)	0.00
Deficiency anemia	40 (2.7)	31 (1.2)	71 (1.7)	0.11
Diabetes, complicated	77 (5.2)	90 (3.5)	167 (4.1)	0.09
Diabetes, uncomplicated	364 (24.4)	605 (23.4)	969 (23.7)	0.02
Fluid and electrolyte disorders	134 (9.0)	197 (7.6)	331 (8.1)	0.05
Hypertension, complicated	39 (2.6)	40 (1.5)	79 (1.9)	0.08
Hypertension, uncomplicated	1281 (85.8)	2089 (80.6)	3370 (82.5)	0.14
Hypothyroidism	317 (21.2)	379 (14.6)	696 (17.0)	0.18
Liver disease	17 (1.1)	36 (1.4)	53 (1.3)	-0.02
Other neurological disorders	57 (3.8)	78 (2.6)	125 (3.1)	0.07
Obesity	192 (12.9)	572 (22.1)	764 (18.7)	-0.24
Paralysis	6 (0.4)	2 (0.1)	8 (0.2)	0.07

Pulmonary circulation disorders	198 (13.3)	268 (10.3)	466 (11.4)	0.09
Peripheral vascular disorders	277 (18.5)	524 (20.2)	801 (19.6)	-0.04
Rheumatoid arthritis/collagen vascular	64 (4.3)	86 (3.3)	150 (3.7)	0.05
Peptic ulcer disease excluding bleeding	11 (0.7)	15 (0.6)	26 (0.6)	0.02
Weight loss	4 (0.3)	7 (0.3)	11 (0.3)	0.00
Emergent or urgent admission	171 (11.5)	356 (13.8)	527 (12.9)	-0.07

SMD, standardized median difference (Cohen's d); SD, standard deviation

Supplementary Material Table 2 –ICD-9 and ICD-10 codes used to specify the sample population and outcomes

Variable	ICD-9-CM or ICD-9-PCS	ICD-10-CM or ICD-10-PCS
Outcomes		
Stroke	"43300", "43301", "43310", "43311", "43320", "43321", "43330", "43331", "43380", "43381", "43390", "43391", "43400", "43401", "43410", "43411", "43490", "43491", "430", "431", "4320", "4321", "4329"	"I6350", "I63239", "I6359", "I63119", "I63019", "I629", "I659", "I6629", "I6509", "I609", "I6200", "I6529", "I6320", "I6609", "I63219", "I6340", "I619", "I651", "I6619", "I669", "I6322", "I6330", "I658", "I63139", "I621"
Transient ischemic attack	"43300", "43301", "43310", "43311", "43320", "43321", "43330", "43331", "43380", "43381", "43390", "43391", "43400", "43401", "43410", "43411", "43490", "43491", "43430", "431", "4320", "4321", "4329", "36234", "4350", "4351", "4352", "4353", "4358", "4359"	"I6350", "I63239", "I6359", "I63119", "I63019", "I629", "I659", "H3400", "I6629", "I6509", "I6200", "I6529", "I6320", "I6609", "I63219", "I6340", "G459", "I619", "I651", "I6619", "I621", "I67848", "I669", "I6322", "I6330", "I658", "I63139", "G458", "G450", "G451"

Bleeding

"4590", "53082", "53100", "53101", "53120",
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"53361", "53400", "53401", "53420", "53421",
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"5693", "5780", "5781", "5789", "59970",
"59971", "6238", "6268", "71910", "71911",
"71912", "71913", "71914", "71915", "71916",
"71917", "71918", "71919", "72992", "7847",
"7848", "78630", "78639", "7847", "99811",
"99812"

"R041", "I97631", "K661", "N99821", "N938", "R042",
"N99820", "K250", "H59129", "M25076", "I97620",
"J95830", "K262", "H59319", "G9752", "H59323",
"H59312", "E89810", "E89811", "I97610", "N9961",
"K91870", "H59122", "H9521", "I97630", "H59333",
"M96831", "H59123", "K270", "H59111", "K91841",
"G9731", "K264", "K56699", "K274", "H59343",
"D7801", "M25049", "N9962", "G9761", "I97611",
"K254", "D7832", "M2508", "K280", "M25069",
"J95861", "K920", "K286", "H9541", "H59341",
"H9542", "R049", "K256", "K91840", "L7622", "R58",
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"H59321", "I97638", "H9551", "D7802", "L7631",
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"K252", "L7602", "K276", "K228", "K9162",
"M96840", "K266", "H59342", "G9762", "M2500",
"L7601", "N898", "H59331", "R319", "H59121",
"L7621", "G9732", "K91871", "L7632", "N99841",
"G9751", "M96811", "J9562", "I97410", "E89820",
"M25059", "N931", "I9742", "H59349", "D7831",
"M96830", "K260", "M25019", "K284", "M25039",
"K282", "K9161", "H59339", "H59329", "E89821",
"M96810", "D7821", "N99840", "H9552", "H9522",
"K921", "M25073", "K922", "J95860", "I97618",
"R040", "H59332", "J95831"

Permanent
pacemaker
implantation

"3781", "3782", "3783", "3794", "0050", "051"

"0JH634Z", "0JPT3PZ", "0JPT0PZ", "0JH837Z",
"0JH635Z", "02H43JZ", "0JH806Z", "02HK3KZ",
"0JH836Z", "0JH607Z", "0JH636Z", "0JH807Z",
"0JH606Z", "0JH605Z", "0JH835Z", "0JH804Z",
"02HN0JZ", "02H64KZ", "0JH604Z", "02PA3MZ",

"02HK4KZ", "02HK3JZ", "0JH637Z", "02H63KZ",
"02H63JZ", "02HN4JZ", "0JH834Z", "0JH805Z"

Rehospitalization "42731", "42732", "4270"

"I4891", "I4892", "I471"

for atrial arrhythmia

Rehospitalization "39891", "40201", "40211", "40291", "40401",
for heart failure "40411", "40491", "40403", "40413", "40493",
"4280", "4281", "42820", "42821", "42822",
"42823", "42830", "42831", "42832", "42833",
"42840", "42841", "42842", "42843", "4289"

"I5082", "I5041", "I50813", "I509", "I5033", "I5043",
"I5084", "I5042", "I5030", "I501", "I130", "I50814",
"I5089", "I5031", "I5020", "I5083", "I5040", "I50812",
"I5021", "I5022", "I110", "I5023", "I5032", "I50810",
"I50811", "I0981", "I132"

Sepsis

"038", "995.91", "995.92", "785.52"

"A409", "A412", "A4101", "A4102", "A411", "A403",
"A414", "A4150", "A413", "A4151", "A4152",
"A4153", "A4159", "A4189", "A419", "A419",
"R6520", "R6521"

Principle selection criteria

Atrial fibrillation "42731"

"I4891", "I48.0", "I48.1", "I48.2"

Heart or lung "3751", "3752", "3753", "3754", "335", "336",
transplant "3350", "3351", "3352"

"0BYL0Z0", "0BYM0Z2", "0BYL0Z2", "0BYG0Z1",
"02RL0JZ", "0BYD0Z1", "0BYG0Z2", "0BYG0Z0",
"0BYC0Z2", "0BYK0Z2", "02RK0JZ", "02YA0Z0",
"0BYF0Z1", "02YA0Z1", "0BYH0Z0", "0BYH0Z1",
"0BYC0Z0", "0BYF0Z0", "0BYC0Z1", "0BYJ0Z2",
"0BYD0Z0", "0BYF0Z2", "0BYH0Z2", "02YA0Z2",
"02WA0JZ", "0BYK0Z0", "0BYM0Z1", "0BYJ0Z1",
"0BYL0Z1", "0BYK0Z1", "0BYM0Z0", "0BYD0Z2",
"0BYJ0Z0"

Major
cardiovascular
procedures

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"02170ZT", "02170AT", "024F07J", "03LS0DZ",
"02WF4JZ", "02LS0ZZ", "021608R", "02120AC",
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"02164JP", "03CN4ZZ", "02164JQ", "02170KT",
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"02RF4KZ", "021V08S", "02170JT", "02WJ48Z",
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"03CC0ZZ", "02RG3JZ", "04C14ZZ", "021609Q",
"02120KC", "03VQ4DZ", "02100KF", "021648R",
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"021309W", "03VL0BZ", "03LQ3DZ", "03VG0DZ",
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Prior surgical or endovascular ablation	"3733", "3734", "3737"	"02BL3ZZ", "02B60ZZ", "02563ZZ", "025K0ZZ", "02BL4ZZ", "02BK0ZZ", "025L4ZZ", "02564ZZ", "02560ZZ", "02573ZZ", "02T80ZZ", "025L0ZZ", "02BK3ZZ", "02B73ZZ", "02570ZZ", "02BL0ZZ", "02B74ZZ", "025K4ZZ", "025K3ZZ", "025L3ZZ", "02B70ZZ", "02B63ZZ", "02B64ZZ", "02574ZZ", "02BK4ZZ"
Prior left atrial appendage excision, destruction, or exclusion	"3736", "3790"	"02L73CK", "02L73DK", "02L74CK", "02L70CK", "02L73ZK", "02573ZK", "02L74ZK", "02B73ZK", "02L70ZK", "02574ZK", "02B70ZK", "02570ZK", "02B74ZK", "02L70DK", "02L74DK"
Mitral valve disease	"7466", "3941", "3962", "3963", "3940", "3960", "3961", "7465", "3940", "3960", "3961", "7465", "3949", "3968", "3969", "4240"	"Q233", "I051", "I080", "I050", "I080", "Q232", "I050", "I080", "Q232", "I058", "I089", "I348", "I340", "I088"
Tricuspid valve disease	"3970"	"I071", "I072", "I078"

Supplementary Material Table 3 – Full description of matched Cox proportional-hazards model with and without multivariable regression for all-cause mortality.

Model	Hazard ratio (95% CI)	p - value
<i>Matched Cox proportional-hazards model</i>		
SAVR-SA	0.61 (0.50 - 0.73)	<0.01
<i>Matched Cox proportional-hazards model with multivariable regression</i>		
SAVR-SA	0.65 (0.53 - 0.79)	<0.01
Age	1.05 (1.03 - 1.07)	<0.01
CHA2DS2-VASC Score	1.09 (0.97 - 1.21)	0.15

Supplementary Material Table 4 – Full description of matched Cox proportional-hazards model with and without multivariable regression for stroke.

Model	Hazard ratio (95% CI)	p - value
<i>Matched Cox proportional-hazards model</i>		
SAVR-SA	1.00 (0.70 -1.43)	1.00
<i>Matched Cox proportional-hazards model with multivariable regression</i>		
SAVR-SA	1.07 (0.74 – 1.54)	0.72
Age	1.02 (1.00 – 1.05)	0.08
CHA2DS2-VASC Score	1.35 (1.12 – 1.63)	<0.01

Supplementary Material Table 5 – Full description of matched Cox proportional-hazards model with and without multivariable regression for transient ischemic attack.

Model	Hazard ratio (95% CI)	p - value
<i>Matched Cox proportional-hazards model</i>		
SAVR-SA	0.98 (0.70 – 1.36)	0.89
<i>Matched Cox proportional-hazards model with multivariable regression</i>		
SAVR-SA	1.05 (0.75 – 1.47)	0.79
Age	1.02 (1.00 – 1.05)	0.09
CHA2DS2-VASC Score	1.39 (1.18 – 1.65)	<0.01

Supplementary Material Table 6 – Full description of matched Cox proportional-hazards model with and without multivariable regression for pacemaker implantation.

Model	Hazard ratio (95% CI)	p - value
<i>Matched Cox proportional-hazards model</i>		
SAVR-SA	0.60 (0.44 – 0.83)	<0.01
<i>Matched Cox proportional-hazards model with multivariable regression</i>		
SAVR-SA	0.62 (0.44 – 0.87)	<0.01
Age	1.02 (0.98 – 1.05)	0.30
CHA2DS2-VASC Score	0.98 (0.82 – 1.17)	0.83

Supplementary Material Table 7 – Full description of matched Cox proportional-hazards model with and without multivariable regression for bleeding.

Model	Hazard ratio (95% CI)	p - value
<i>Matched Cox proportional-hazards model</i>		
SAVR-SA	0.61 (0.39 – 0.96)	0.03
<i>Matched Cox proportional-hazards model with multivariable regression</i>		
SAVR-SA	0.63 (0.39 – 1.01)	0.05
Age	1.01 (0.98 – 1.04)	0.41
CHA2DS2-VASC Score	1.08 (0.87 – 1.35)	0.48

Supplementary Material Table 8 – Full description of matched Cox proportional-hazards model with and without multivariable regression for rehospitalization for atrial arrhythmia (landmarked at 180 days).

Model	Hazard ratio (95% CI)	p - value
<i>Matched Cox proportional-hazards model</i>		
SAVR-SA	0.85 (0.65 – 1.11)	0.24
<i>Matched Cox proportional-hazards model with multivariable regression</i>		
SAVR-SA	0.91 (0.68 – 1.21)	0.50
Age	1.05 (1.02 – 1.08)	<0.01
CHA2DS2-VASC Score	0.98 (0.86 – 1.11)	0.72

Supplementary Material Table 9 – Full description of matched Cox proportional-hazards model with and without multivariable regression for rehospitalization for heart failure (landmarked at 180 days).

Model	Hazard ratio (95% CI)	p - value
<i>Matched Cox proportional-hazards model</i>		
SAVR-SA	0.47 (0.35 – 0.62)	<0.01
<i>Matched Cox proportional-hazards model with multivariable regression</i>		
SAVR-SA	0.49 (0.36 – 0.65)	<0.01
Age	1.02 (0.99 – 1.04)	0.18
CHA2DS2-VASC Score	1.26 (1.10 – 1.43)	<0.01

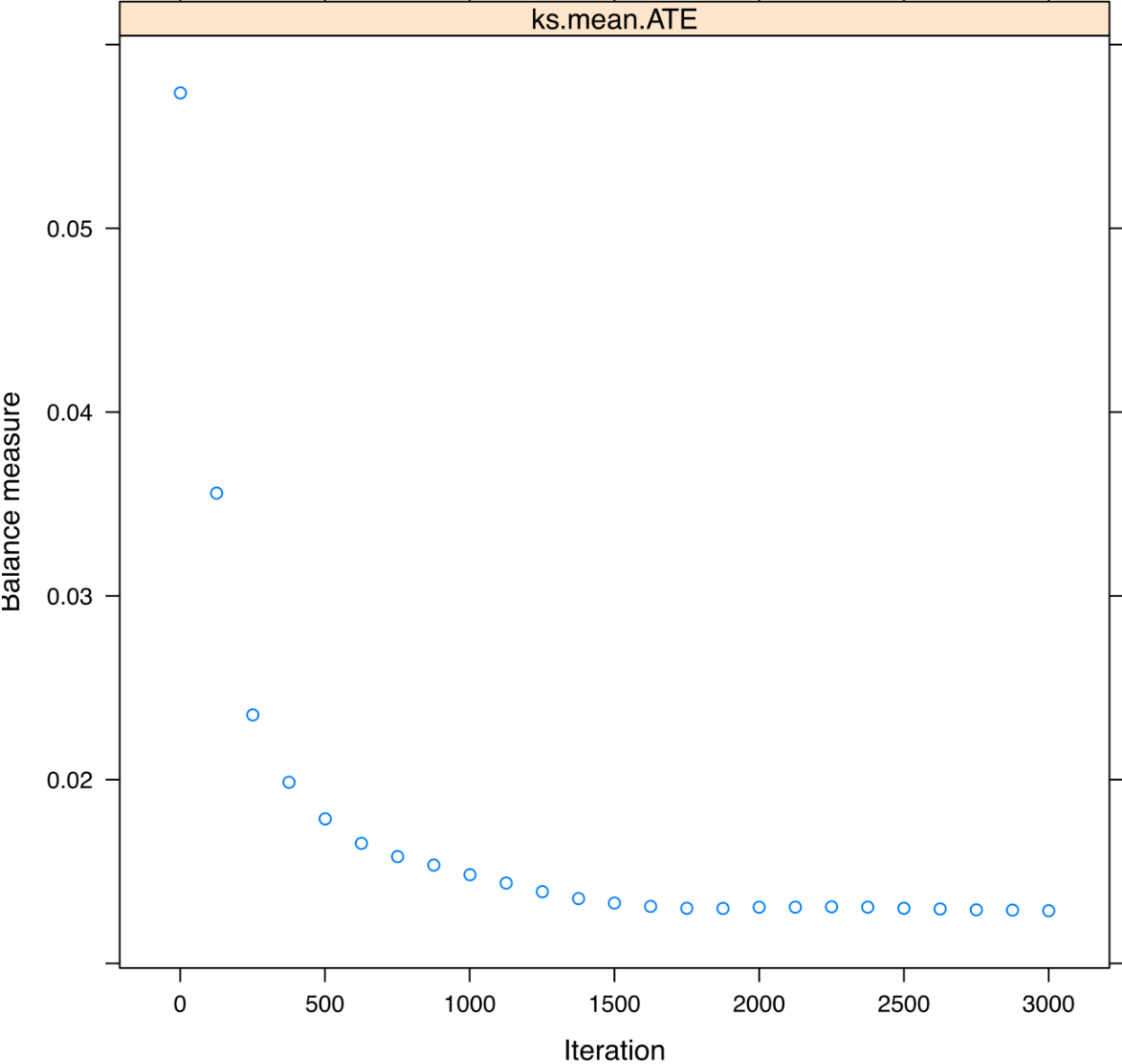
Supplementary Material Table 10 – Full description of matched Cox proportional-hazards model with and without multivariable regression for rehospitalization for sepsis (landmarked at 180 days).

Model	Hazard ratio (95% CI)	p - value
<i>Matched Cox proportional-hazards model</i>		
SAVR-SA	1.13 (0.82 – 1.55)	0.45
<i>Matched Cox proportional-hazards model with multivariable regression</i>		
SAVR-SA	1.18 (0.84 – 1.65)	0.33
Age	1.03 (1.00 – 1.07)	0.12
CHA2DS2-VASC Score	1.07 (0.89 – 1.28)	0.49

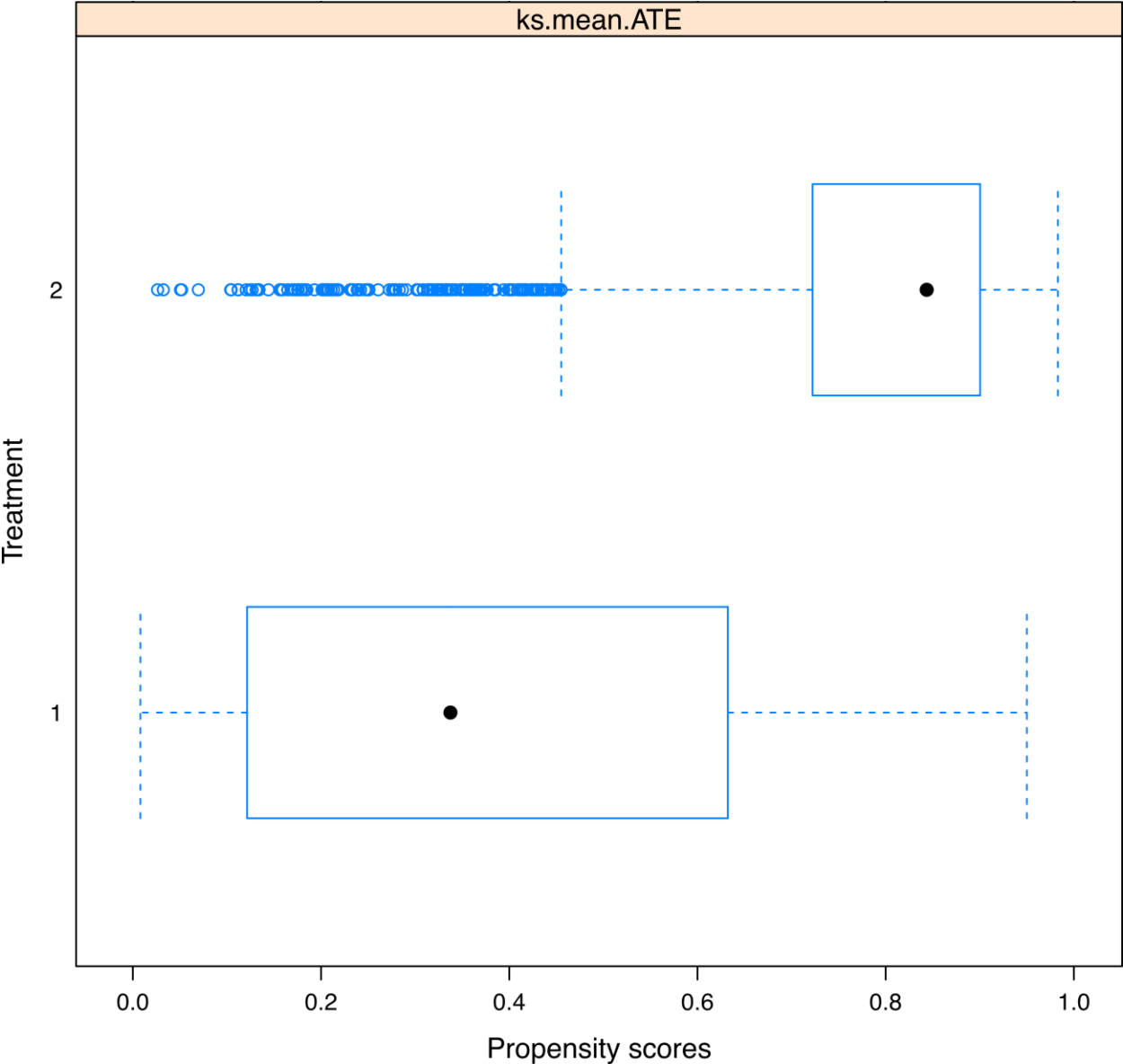
Supplementary Material Figure 1 – Generalized boosted regression model optimization

Parameters:

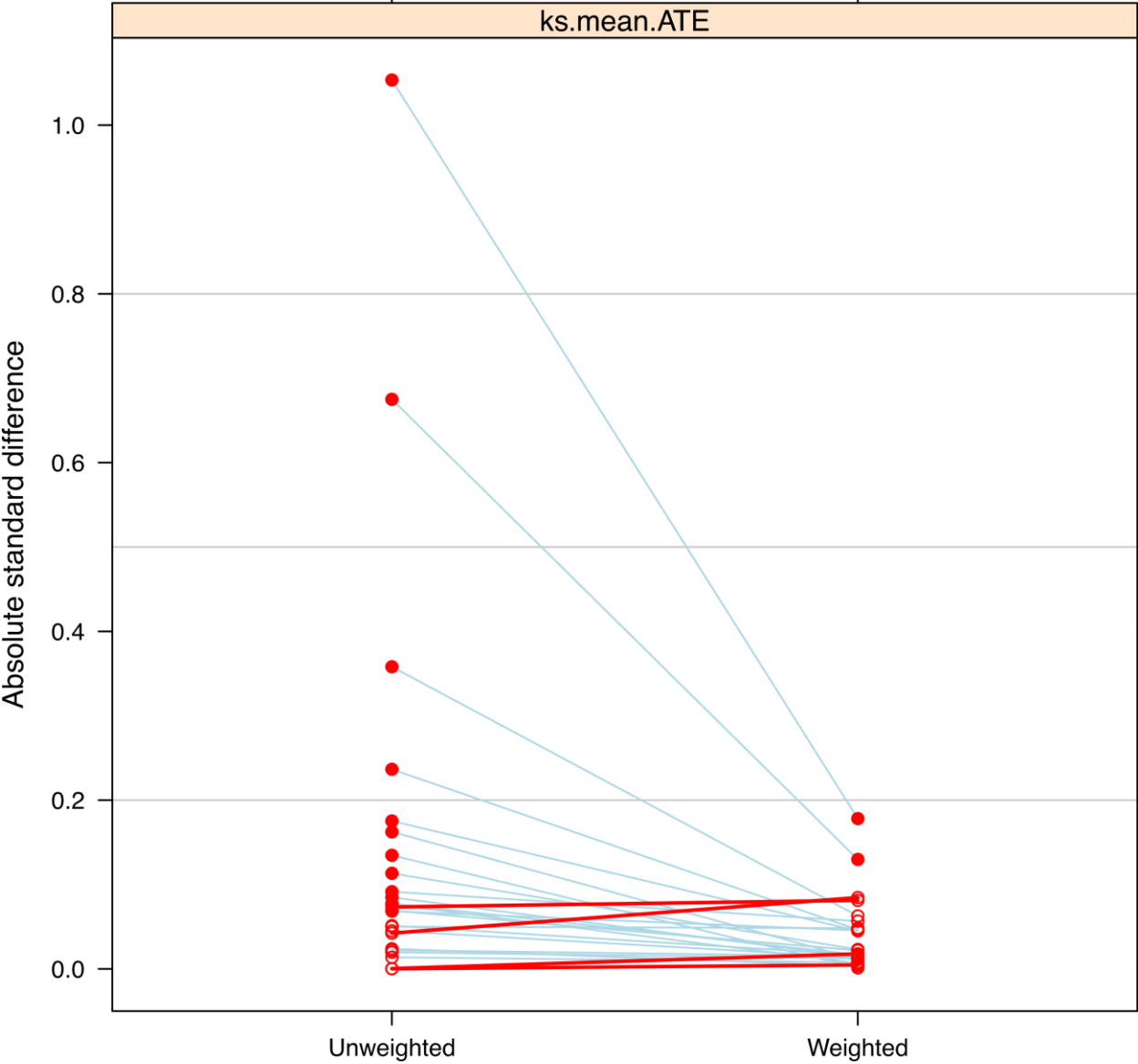
- Number of trees = 3,000
- Interaction depth = 3
- Shrinkage = 0.01



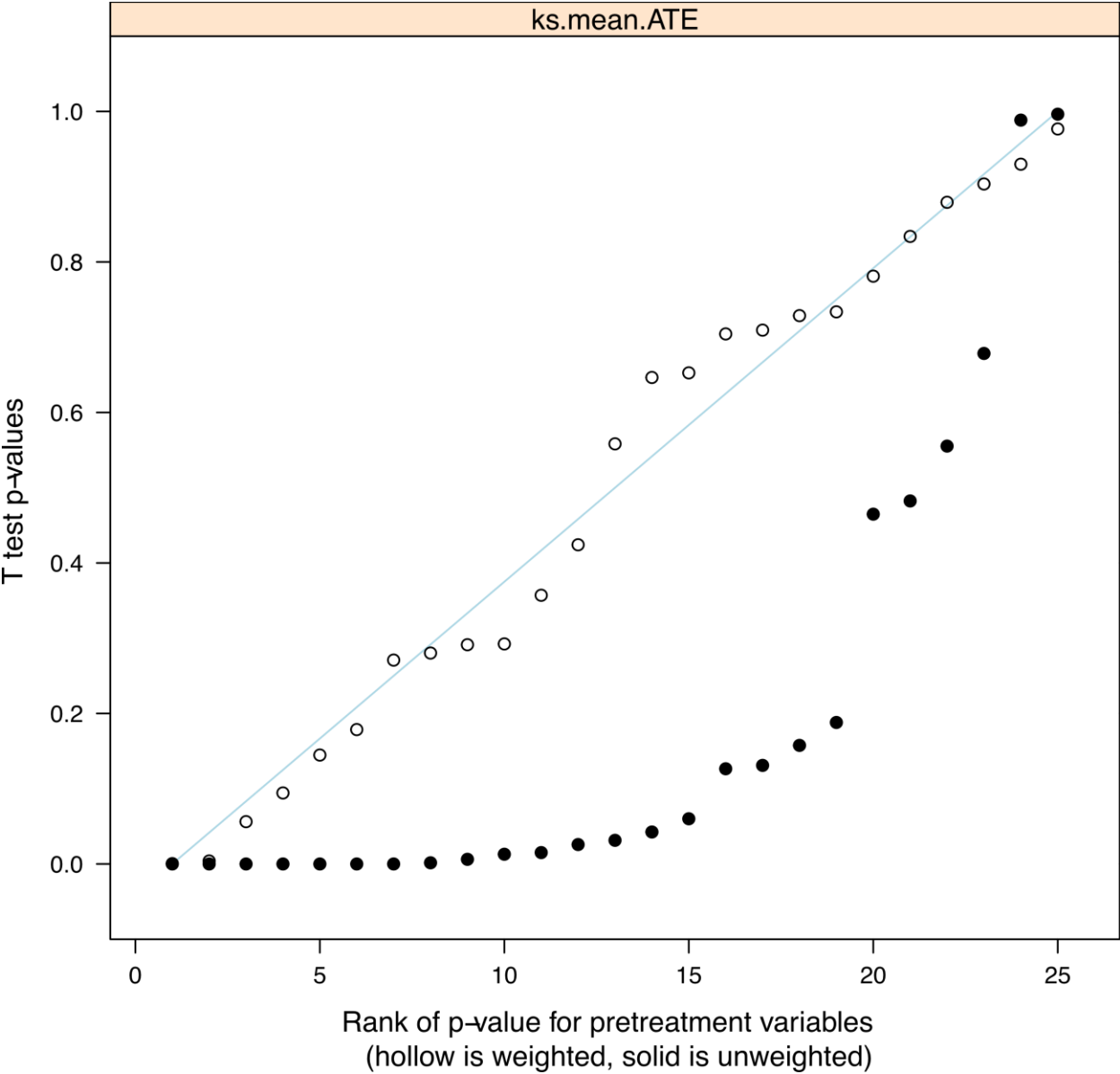
Supplementary Material Figure 2 – Boxplot of propensity score generated from the boosted regression model where 2 = TAVR and 1 = SAVR-SA.



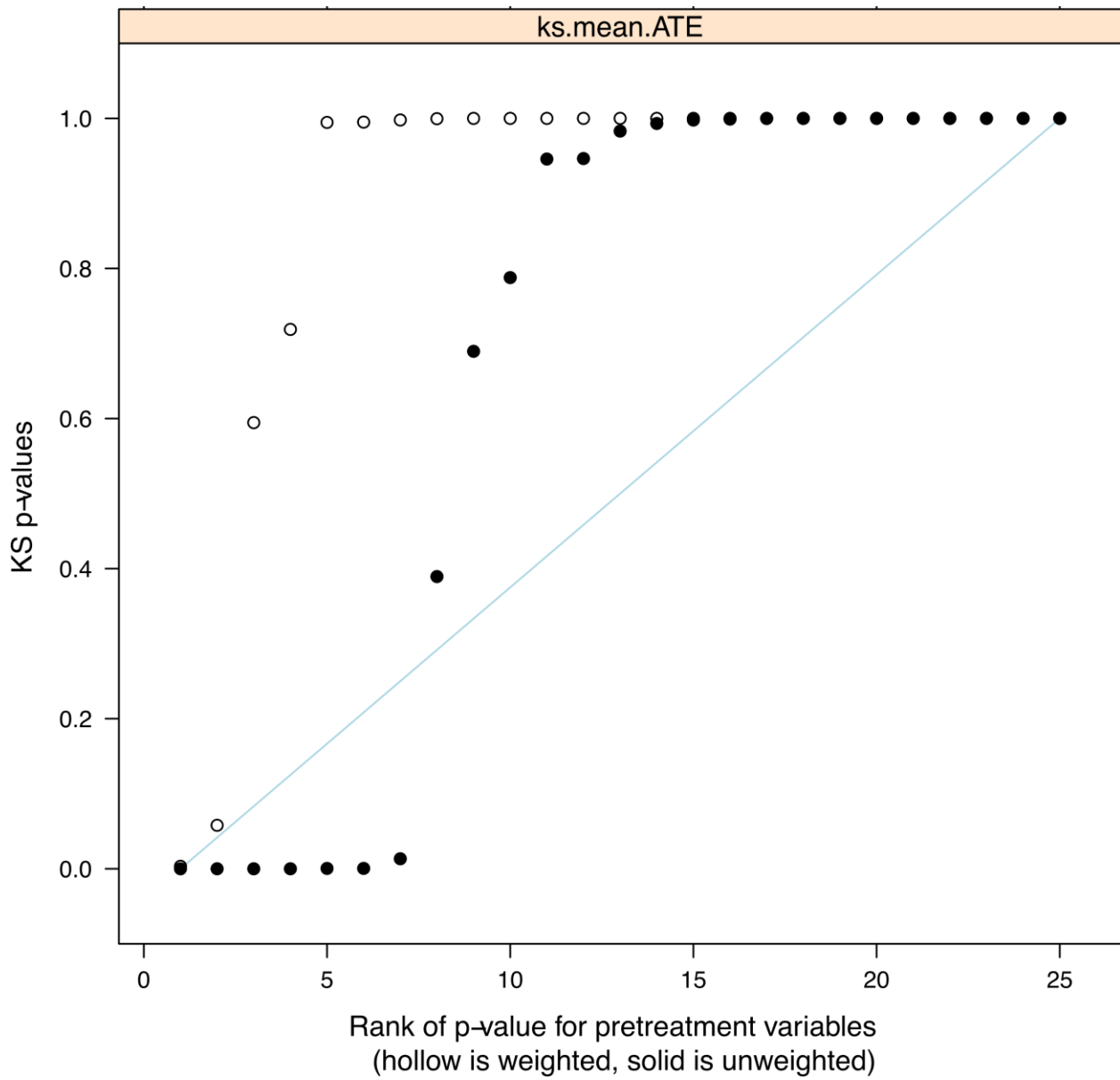
Supplementary Material Figure 3 – Standardized effect sizes before and after weighting.



Supplementary Material Figure 4 – P-values of t-tests between group means of covariates.



Supplementary Material Figure 5 – Kolmogorov-Smirnov p-values for weighted and unweighted cohorts.



Supplementary Material Figure 6 – Cumulative incidence of sepsis with death as a competing risk, landmarked at 180 days, stratified by procedure type. The statistically equivalent cumulative incidence of sepsis overtime suggest that the matched treatment groups were similar with respect to observed and unobserved confounders.

