Supplementary Information

A multi-institutional study using artificial intelligence to provide reliable and fair feedback to surgeons

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	needle handling			needle driving		
	USC	SAH	HMH	USC	SAH	HMH
video samples	26	8	11	27.5	7	14
video explanations	8	3	4	8	3	4
explanation percentage %	31	38	36	29	43	29

Supplementary Table 1. Average duration (seconds) of video samples and explanations. We present the average duration of video samples and explanations of the needle handling and needle driving surgical activities across hospitals. The percentage reflects the proportion of the video sample which is deemed as important by the trained human raters.

Fold	train			validation			test		
	n	v	s	n	v	s	n	v	s
0	748	63	17	82	7	6	82	8	4
1	752	63	18	82	7	5	78	8	6
2	778	63	16	44	7	6	90	8	6
3	730	63	18	102	7	6	80	8	6
4	728	63	17	60	7	5	124	8	7
5	774	63	16	46	7	6	92	8	6
6	724	63	16	102	7	6	86	8	8
7	752	63	16	102	7	5	58	8	6
8	754	63	19	86	7	6	72	8	5
9	756	63	17	90	7	4	66	8	6

Fold	train			validation			test		
	n	v	s	n	v	s	n	v	s
0	442	63	17	42	7	6	46	8	4
1	438	63	18	42	7	5	50	8	6
2	432	63	16	44	7	6	54	8	6
3	452	63	18	42	7	6	36	8	6
4	438	62	17	38	7	5	54	8	7
5	448	63	16	30	7	6	52	8	6
6	400	63	16	62	7	6	68	8	8
7	450	63	16	54	7	5	26	8	6
8	408	63	19	48	7	6	74	8	5
9	412	63	17	58	7	4	60	8	6

Supplementary Table 2. Number of video samples (n), unique surgical videos (v), and surgeons (s) in each fold and data split at USC. We used these samples in the 10-fold Monte Carlo cross-validation setup to train and evaluate SAIS in assessing the skill-level of needle handling (left) and needle driving (right).

	caseload						prostate volume						Gleason score								
	novice			expert			$\leq$ 49ml			$>$ 49ml			6			7			8		
Fold	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s
0	14	3	3	25	6	3	10	2	2	31	6	5	14	2	3	9	3	4	18	3	2
1	17	3	3	21	5	4	17	5	5	22	3	4	16	3	4	17	4	5	6	1	1
2	15	3	3	22	6	5	22	4	4	23	4	6	18	2	2	14	4	5	8	1	1
3	31	6	5	8	3	3	30	6	6	10	2	4	13	3	3	23	4	6	4	1	1
4	33	5	4	21	3	2	24	4	4	38	4	4	20	3	3	34	4	4	8	1	1
5	4	1	1	40	6	6	23	3	3	12	4	4	2	1	1	32	5	5	12	2	2
6	27	4	4	14	5	5	8	3	3	35	5	7	3	2	2	35	4	6	5	2	2
7	7	2	2	20	5	5	12	4	4	17	4	4	14	3	3	15	5	5			
8	16	2	2	20	7	7	22	4	5	14	4	4				21	4	5	15	4	4
9	13	3	3	17	6	4	7	2	3	26	6	6	10	1	2	15	5	6	3	1	1

Supplementary Table 3. Number of video samples (n), unique surgical videos (v), and surgeons (s) in each test fold across surgeons groups when assessing the skill-level of needle handling. We used these samples when stratifying the reliability of explanations across surgeon groups.

	caseload						prostate volume						Gleason score								
	novice			expert			$\leq$ 49ml			$>$ 49ml			6			7			8		
Fold	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s
0	5	3	3	18	6	3	6	1	1	17	6	5	6	2	3	5	2	3	12	3	2
1	5	2	2	19	5	5	11	4	5	14	3	4	10	3	4	10	3	5	5	1	1
2	10	2	2	15	6	5	14	4	4	13	4	5	6	2	2	16	4	4	2	1	1
3	13	3	3	4	3	3	10	4	4	8	2	3	5	2	2	11	3	4	2	1	1
4	16	4	4	9	3	2	8	3	3	19	4	4	6	2	2	19	4	4	2	1	1
5	4	1	1	22	7	7	15	3	4	7	3	3				19	5	6	7	2	2
6	21	3	3	13	5	5	10	3	3	24	4	5	1	1	1	22	4	5	11	2	2
7	1	1	1	12	4	4	6	2	2	7	3	3	6	3	3	7	2	2			
8	9	2	2	28	6	6	20	4	6	17	4	3				15	4	4	22	4	4
9	7	2	2	19	7	5	9	2	4	21	6	5	5	1	2	15	5	6	7	1	1

Supplementary Table 4. Number of video samples (n), unique surgical videos (v), and surgeons (s) in each test fold across surgeons groups when assessing the skill-level of needle driving at USC. We used these samples when stratifying the reliability of explanations across surgeon groups.

	prostate volume						Gleason score											
	$\leq$ 49ml			$>$ 49ml			6			7			8			9		
	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s
handling	81	18	5	39	9	4	23	7	4	66	13	5	18	5	3	13	2	2
driving	88	18	5	52	9	4	49	7	4	67	13	5	17	5	3	7	2	2

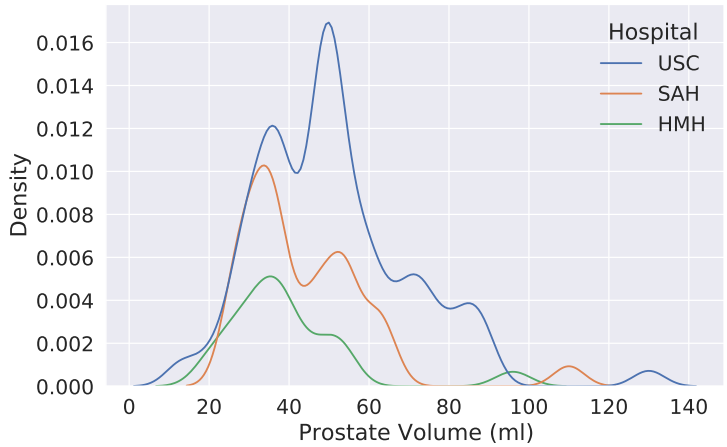
Supplementary Table 5. Number of video samples in each surgeon group from St. Antonius Hospital. We used these video samples to stratify the reliability of explanations (whether attention-based or TWIX) across surgeon sub-cohorts.

	caseload						prostate volume						Gleason score											
	novice			expert			$\leq$ 49ml			$>$ 49ml			6			7			8			9		
	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s	n	v	s
handling	36	10	1	49	10	3	53	13	3	16	3	2	2	1	1	61	14	4	17	4	2	5	1	1
driving	57	10	1	46	10	3	71	13	3	16	3	2	4	1	1	61	14	4	31	4	2	7	1	1

Supplementary Table 6. Number of video samples in each surgeon group from Houston Methodist Hospital. We used these video samples to stratify the reliability of explanations (whether attention-based or TWIX) across surgeon sub-cohorts.

	gender					
	male			female		
	n	v	s	n	v	s
handling	64	29	17	100	40	21

Supplementary Table 7. Number of video samples in each group from the laboratory environment. We used these video samples to stratify the reliability of explanations (whether attention-based or TWIX) across sub-cohorts.



Supplementary Figure 1. Distribution of prostate volume of patients across the three hospitals. These distributions are based on the total number of video samples from each hospital. Note the difference in the average prostate volume across hospitals.