

Applications of enhanced recovery after surgery protocols for unruptured anterior circulation aneurysms in tertiary-level healthcare institutions: a national study

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OBJECTIVE Enhanced recovery after surgery (ERAS) protocols are standardized perioperative care that reduce patients' stress response during hospitalization and improve hospitalization time, complication rates, costs, and readmission rates. This study aimed to investigate the application rate of protocols for elective craniotomy in the surgery of unruptured anterior circulation aneurysms (AnCAs) at tertiary-level healthcare (TLH) institutions in Türkiye and its effect on the outcomes of the patients.

METHODS An electronic survey was sent to all Turkish TLH institutions (n = 127) between May and June 2023. The number of institutions participating in the survey was 38 (30%). The institutions were subdivided according to three main factors: institution type (university hospital [UH] vs training and research hospital [TRH]), annual case volume (low [≤ 20 aneurysms] vs high [> 20 aneurysms]), and institution accreditation status (accredited vs nonaccredited).

RESULTS Overall, 55.3% (n = 21) of the institutions participating in the study were UHs. The rates of those that were accredited and had a high case volume were 55.3% (n = 21) and 31.6% (n = 12), respectively. It was determined that the accredited clinics applied preoperative protocols at a higher rate (p = 0.050), and the length of stay in the postoperative period was shorter in the clinics that used the intraoperative protocols (p = 0.014).

CONCLUSIONS The length of stay in the postoperative period is lower in TLH institutions in Türkiye that highly implement intraoperative protocols. Furthermore, this is the first study in the literature evaluating protocols for elective craniotomy in unruptured AnCAs.

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KEYWORDS protocols; recovery; aneurysm

HEALTH services in Türkiye are categorized into three levels.¹ Elective aneurysm surgery can only be performed at tertiary-level healthcare (TLH) institutions. State university hospitals (UHs), private UHs, training and research hospitals (TRHs), and city hospitals constitute TLH institutions. Today, there are more than 100 institutions in Türkiye that meet TLH criteria.

Enhanced recovery after surgery (ERAS) protocols include standardized multidisciplinary and patient-centered care items for the preoperative, intraoperative, and postoperative periods.² The benefits of ERAS protocols for neurosurgical procedures are reducing metabolic stress, maintaining fluid homeostasis, and reducing postoperative

inflammation.³ Many recent publications^{4,5} documented that ERAS protocols improve outcomes and functional independence by reducing the hospital length of stay (LOS), complication rates, and costs after abdominal surgeries. In neurosurgery, ERAS protocol usage is predominant in spinal surgery.^{2,6-9} However, the frequency of its application in cranial surgery^{2,10} is increasing gradually. Two comprehensive systematic reviews for craniotomy were recently published,^{10,11} but ERAS protocols have only been reported by Han et al. for aneurysm surgery.¹² Our aim in this study was to investigate the awareness and utility of protocols for the surgery of unruptured anterior circulation aneurysms (AnCAs) in Turkish TLH institutions.

ABBREVIATIONS AnCA = anterior circulation aneurysm; ERAS = enhanced recovery after surgery; LOS = length of stay; TLH = tertiary-level healthcare; TRH = training and research hospital; UH = university hospital.

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TABLE 1. Protocol overview

	Value*
Institute type	
UH	21 (55.3)
TRH	17 (44.7)
Dept accredited	
No	17 (44.7)
Yes	21 (55.3)
No. of unruptured AnCAs clipped annually in the dept	
≤20	26 (68.4)
>20	12 (31.6)
Standard ERAS protocols for unruptured AnCA surgery applied in the dept	
No	24 (63.2)
Yes	14 (36.8)
Mean total hospital LOS, days	
<4	3 (7.9)
4–10	28 (73.7)
>10	7 (18.4)
Mean postop hospital LOS, days	
<4	9 (23.7)
4–10	26 (68.4)
>10	3 (7.9)
% pts w/ moderate to severe pain	
≤5%	11 (28.9)
>5%	27 (71.1)
Readmission rate	
≤5%	32 (84.2)
>5%	6 (15.8)
Total complication rate	
≤5%	24 (63.2)
>5%	14 (36.8)
Compliance w/ preop protocols, %	
Mean ± SD	44.64 ± 18.28
Median (min-max)	44.64 (7.14–85.71)
Compliance w/ intraop protocols	
Mean ± SD	78.05 ± 15.34
Median (min-max)	84.21 (39.47–97.37)
Compliance w/ postop protocols	
Mean ± SD	64.95 ± 15.49
Median (min-max)	63.83 (38.30–91.49)
Overall compliance w/ protocols	
Mean ± SD	64.32 ± 14.48
Median (min-max)	66.37 (38.94–91.15)

Dept = department; pt = patient.

* Presented as the number of patients (%) unless stated otherwise.

Methods

Online Survey

An electronic survey was created by revising the protocol proposed by Wang et al. (Online Survey).¹³ The pro-

ocol consists of 9 main topics: preoperative evaluation, preoperative nursing, operating room nursing, anesthesia management, surgical manipulations, postoperative management, postoperative nursing management, discharge evaluation, and follow-up. We added the following items that are specific to aneurysm surgery to this protocol for elective craniotomy: use of intraoperative digital subtraction angiography and/or indocyanine green video angiography, postoperative CT angiography and/or digital subtraction angiography, daily transcranial Doppler ultrasonography, and oral/intravenous nimodipine.

The link to this survey was sent to the neurosurgery departments at all 127 Turkish TLH institutions. The number of institutions participating in the survey was 38 (30%). The participants were informed about the confidentiality of their data. All data were collected in an online database and then imported into Microsoft Excel. The survey was in Turkish as the native language.

Subgrouping of Questions and Institutions

Questions were categorized into three groups: 1) baseline institutional characteristics; 2) perioperative data and outcomes; and 3) pre-, intra-, and postoperative protocols. Institutions were subdivided according to three main factors: institution type (UH vs TRH), annual case volume (low [≤ 20 aneurysms] vs high [> 20 aneurysms]), and institution accreditation status (accredited vs nonaccredited). The institutions were divided into UHs and TRHs because the operating layout is the only difference between TRHs and city hospitals. All other features are the same.

Statistical Analysis

SPSS version 11.5 (SPSS Inc.) was used for statistical analysis. Mean ± SD and median (minimum-maximum) were used as descriptors for quantitative variables and the number of patients (percentage) for qualitative variables. Whether there was a difference between the categories of the qualitative variable with two categories in terms of quantitative variable was examined using the Student t-test if normal distribution assumptions were met and the Mann-Whitney U-test if not. The Kruskal-Wallis H-test was used to determine whether there was a difference between the categories of the qualitative variable with more than two categories in terms of the quantitative variable since the assumptions of normal distribution were not met. Statistical significance was set at $p \leq 0.05$.

Results

Baseline Characteristics

Overall, 55.3% (n = 21) of the departments participating in the study were in UHs, and 55.3% (n = 21) were accredited. The number of high-volume departments was 12 (31.6%), and ERAS protocols were applied in 14 (36.8%) departments. Total and postoperative LOSs were most often 4–10 days (73.7% and 68.4%, respectively). The pain status, readmission rate, complication rate, and compliance rate of the protocols are given in Table 1 in detail.

Compliance With Protocols

Nine variables in Table 1 and preoperative, intraopera-

TABLE 2. Comparison of variables and compliance rates with preoperative protocols

	Preop Protocols		p Value
	Mean \pm SD	Median (min-max)	
Institute type			
UH	49.15 \pm 19.69	42.86 (25.00–85.71)	0.199*
TRH	39.08 \pm 15.12	46.43 (7.14–64.29)	
Dept accredited			
No	38.24 \pm 15.45	39.29 (7.14–71.43)	0.050†
Yes	49.83 \pm 19.08	50.00 (25.00–85.71)	
No. of unruptured AnCAs clipped annually in the dept			
≤ 20	45.86 \pm 19.94	42.86 (7.14–85.71)	0.547†
> 20	41.96 \pm 14.46	46.43 (21.43–64.29)	
Standard ERAS protocols for unruptured AnCA surgery applied in the dept			
No	42.71 \pm 20.05	35.71 (7.14–78.57)	0.260*
Yes	47.96 \pm 14.87	46.43 (25.00–85.71)	
Mean total hospital LOS, days			
< 4	51.19 \pm 5.46	50.00 (46.43–57.14)	0.506‡
4–10	43.11 \pm 18.57	41.07 (7.14–85.71)	
> 10	47.96 \pm 21.31	42.86 (21.43–78.57)	
Mean postop hospital LOS, days			
< 4	51.19 \pm 15.36	46.43 (32.14–75.00)	0.404‡
4–10	42.58 \pm 19.03	37.50 (7.14–85.71)	
> 10	42.86 \pm 21.43	42.86 (21.43–64.29)	
% pts w/ moderate to severe pain			
$\leq 5\%$	42.86 \pm 17.50	46.43 (7.14–75.00)	0.874*
$> 5\%$	45.37 \pm 18.87	42.86 (21.43–85.71)	
Readmission rate			
$\leq 5\%$	45.42 \pm 19.16	46.43 (7.14–85.71)	0.550†
$> 5\%$	40.48 \pm 13.11	35.71 (28.57–64.29)	
Total complication rate			
$\leq 5\%$	43.90 \pm 19.86	44.64 (7.14–85.71)	0.747†
$> 5\%$	45.92 \pm 15.84	44.64 (25.00–78.57)	

Boldface type indicates statistical significance.

* Mann-Whitney U-test.

† Student t-test.

‡ Kruskal-Wallis H-test.

tive, postoperative, and overall protocol compliance rates were compared. It was found that the preoperative protocol compliance rate of accredited departments was statistically significantly higher ($p = 0.050$) (Table 2). It was also found that the postoperative hospital LOS was significantly shorter in departments with high compliance rates for intraoperative protocols ($p = 0.014$) (Table 3). When the postoperative period (Table 4) and overall (Table 5) compliance were compared with the same variables, no difference was found between departments.

Discussion

ERAS protocols are associated with short inpatient hospital stays, reduced complications, and decreased financial costs. Flukes et al. found that applying intraopera-

tive protocols shortened the hospital stay in the postoperative period.¹⁴ However, our study is the first in the literature on implementing protocols for elective craniotomy in unruptured AnCAs.

Han et al.¹² compared ERAS protocols and conventional management in 300 elderly aneurysm patients. Glasgow Outcome Scale and modified Rankin Scale scores were improved in the ERAS group without increasing the mortality or readmission. Patients aged 64–67 years were included in this study, and no information about aneurysm rupture status was provided. However, our study included only unruptured AnCAs from all age groups.

A recent survey among European neurosurgeons found that ERAS protocols were implemented in 36% of health-care centers.¹⁵ Similarly, this rate was 36.8% among the

TABLE 3. Comparison of variables and compliance rates with intraoperative protocols

	Intraop Protocols		p Value
	Mean \pm SD	Median (min-max)	
Institute type			
UH	81.08 \pm 15.76	86.84 (44.74–97.37)	0.060*
TRH	74.30 \pm 14.37	78.95 (39.47–94.74)	
Dept accredited			
No	76.16 \pm 17.24	84.21 (39.47–94.74)	0.642*
Yes	79.57 \pm 13.85	84.21 (47.37–97.37)	
No. of unruptured AnCAs clipped annually in the dept			
≤ 20	77.13 \pm 16.24	81.58 (39.47–97.37)	0.745*
> 20	80.04 \pm 13.63	84.21 (57.89–97.37)	
Standard ERAS protocols for unruptured AnCA surgery applied in the dept			
No	75.22 \pm 17.16	82.89 (39.47–97.37)	0.260*
Yes	82.89 \pm 10.41	84.21 (60.53–97.37)	
Mean total hospital LOS, days			
< 4	92.11 \pm 6.96	94.74 (84.21–97.37)	0.121†
4–10	76.03 \pm 15.47	80.26 (39.47–97.37)	
> 10	80.08 \pm 15.33	84.21 (57.89–94.74)	
Mean postop hospital LOS, days			
< 4	88.89 \pm 6.00	89.47 (78.95–97.37)	0.014†
4–10	73.68 \pm 15.70	77.63 (39.47–97.37)	
> 10	83.33 \pm 17.52	92.11 (63.16–94.74)	
% pts w/ moderate to severe pain			
$\leq 5\%$	72.97 \pm 18.12	78.95 (39.47–92.11)	0.278*
$> 5\%$	80.12 \pm 13.89	84.21 (47.37–97.37)	
Readmission rate			
$\leq 5\%$	78.45 \pm 15.20	84.21 (39.47–97.37)	0.740*
$> 5\%$	75.88 \pm 17.33	76.32 (47.37–94.74)	
Total complication rate			
$\leq 5\%$	77.19 \pm 16.36	82.89 (39.47–97.37)	0.940*
$> 5\%$	79.51 \pm 13.86	84.21 (44.74–94.74)	

Boldface type indicates statistical significance.

* Mann-Whitney U-test.

† Kruskal-Wallis H-test.

departments participating in our survey. Nevertheless, interestingly, the overall rate of compliance with ERAS protocols was 64.3%. This situation can be interpreted in two ways: those who fill out the questionnaire do not know these protocols, or some protocols are already taken for granted, even though they are not called ERAS protocols. The fact that the preoperative protocol compliance rate is significantly higher in accredited clinics is attributed to the accreditation boards' frequent inspection of these clinics. A high total compliance rate of 64.3% also shortened the hospital LOS in the postoperative period.

Despite recognizing the benefits of ERAS protocols, the main challenge in daily practice is coordinating the patient care team from the preoperative to the postoperative period. The patient care team should include medical physicians, surgeons, nurses, physical therapists, social

workers, and preadmission staff.⁷ In addition, the increased workload in hospitals, the lack of staff, and the lack of standardization due to the nonaccreditation of the clinics are other possible challenges. When the answers to our survey were examined in detail, the least applied protocol items were determining the nutritional status, anxiety/depression scales, and teaching breathing exercises. We speculate that this situation is due to the lack of coordination, the lack of staff, and the high workload.

The accumulating literature on the usefulness of ERAS protocols will increase their use over time, but this will reveal the need for standardization. In our revision of the protocols of Wang et al.¹³ in our study, we preferred the term “protocols for elective craniotomy” over “ERAS protocol.” A recent systematic review¹¹ evaluated 9 studies of cranial surgery with ERAS protocols. The different pro-

TABLE 4. Comparison of variables and compliance rates with postoperative protocols

	Postop Protocols		p Value
	Mean \pm SD	Median (min-max)	
Institute type			
UH	68.59 \pm 16.42	68.09 (42.55–91.49)	0.108*
TRH	60.45 \pm 13.37	61.70 (38.30–80.85)	
Dept accredited			
No	61.58 \pm 14.42	65.96 (38.30–82.98)	0.232*
Yes	67.68 \pm 16.13	61.70 (42.55–91.49)	
No. of unruptured AnCAs clipped annually in the dept			
≤ 20	64.98 \pm 16.25	63.83 (42.55–91.49)	0.988*
> 20	64.89 \pm 14.39	63.83 (38.30–89.36)	
Standard ERAS protocols for unruptured AnCA surgery applied in the dept			
No	63.39 \pm 15.53	61.70 (38.30–89.36)	0.423*
Yes	67.63 \pm 15.62	67.02 (44.68–91.49)	
Mean total hospital LOS, days			
< 4	78.01 \pm 11.72	78.72 (65.96–89.36)	0.122†
4–10	61.93 \pm 14.14	61.70 (42.55–89.36)	
> 10	71.43 \pm 18.91	80.85 (38.30–91.49)	
Mean postop hospital LOS, days			
< 4	70.92 \pm 10.58	65.96 (59.57–89.36)	0.282†
4–10	62.19 \pm 15.13	61.70 (42.55–89.36)	
> 10	70.92 \pm 28.57	82.98 (38.30–91.49)	
% pts w/ moderate to severe pain			
$\leq 5\%$	60.93 \pm 15.11	59.57 (42.55–82.98)	0.314*
$> 5\%$	66.59 \pm 15.62	65.96 (38.30–91.49)	
Readmission rate			
$\leq 5\%$	65.69 \pm 15.39	65.96 (38.30–89.36)	0.399‡
$> 5\%$	60.99 \pm 16.90	57.45 (42.55–91.49)	
Total complication rate			
$\leq 5\%$	63.12 \pm 16.63	61.70 (38.30–89.36)	0.348*
$> 5\%$	68.09 \pm 13.30	67.02 (44.68–91.49)	

* Student t-test.

† Kruskal-Wallis H-test.

‡ Mann-Whitney U-test.

protocols used in the studies produced different results. The most commonly used ERAS element in the studies was optimizing the formal discharge criteria, and the least was fasting/carbohydrate loading and antithrombotic prophylaxis. Complication rates were similar in the ERAS and non-ERAS groups, and the LOS was shorter in the ERAS groups with comparable or improved patient satisfaction. However, publications have also reported statistically significant satisfaction in the ERAS group.¹⁶ It has been stated that ERAS protocols effectively reduce postoperative pain¹⁶ in cranial cases, but there was no similar result in our study to support this finding. Nevertheless, the increase in multicenter, randomized controlled trials with subsequent meta-analyses will contribute to the guideline of international neurosurgery associations.¹⁷

The main limitations of our study are that it was con-

ducted on a survey, the institutions participating in the study had different facilities, and the levels of surgical experience differed. There was a relatively low survey response, but enough data could be obtained for statistical analysis. Since the participation in our survey was voluntary, the reluctance of those who needed more knowledge about the subject to fill out the survey may have caused bias in the sample. Voluntary participation also led to a lack of ability to confirm results. In addition, although each step of the protocols was asked of the participants, it was impossible to perform statistical analysis for each separately due to the abundance of data. Thus, statistical analysis was evaluated on compliance rates with preoperative, intraoperative, postoperative, and overall protocols. When each part of the survey was evaluated individually, the most frequently applied records and protocols were the informed

TABLE 5. Comparison of variables and compliance rates with overall protocols

	Overall Protocols		p Value
	Mean \pm SD	Median (min-max)	
Institute type			
UH	67.97 \pm 15.54	69.91 (42.48–91.15)	0.084*
TRH	59.81 \pm 11.99	62.83 (38.94–77.88)	
Dept accredited			
No	60.70 \pm 13.84	67.26 (38.94–76.99)	0.268†
Yes	67.26 \pm 14.63	65.49 (42.48–91.15)	
No. of unruptured AnCAs clipped annually in the dept			
\leq 20	64.33 \pm 15.44	65.04 (38.94–91.15)	0.996*
>20	64.31 \pm 12.76	66.37 (42.48–84.07)	
Standard ERAS protocols for unruptured AnCA surgery applied in the dept			
No	62.24 \pm 15.66	61.95 (38.94–86.73)	0.251*
Yes	67.89 \pm 11.86	67.26 (47.79–91.15)	
Mean total hospital LOS, days			
<4	76.11 \pm 7.02	73.45 (70.80–84.07)	0.157‡
4–10	62.01 \pm 13.82	63.72 (38.94–91.15)	
>10	68.52 \pm 17.36	76.99 (42.48–86.73)	
Mean postop hospital LOS, days			
<4	72.07 \pm 7.85	70.80 (60.18–84.07)	0.118‡
4–10	61.20 \pm 14.70	58.85 (38.94–91.15)	
>10	68.14 \pm 22.58	76.99 (42.48–84.96)	
% pts w/ moderate to severe pain			
\leq 5%	60.50 \pm 14.86	65.49 (38.94–82.30)	0.305*
>5%	65.88 \pm 14.30	67.26 (42.48–91.15)	
Readmission rate			
\leq 5%	64.96 \pm 14.55	67.26 (38.94–91.15)	0.493†
>5%	60.91 \pm 14.88	56.64 (42.48–84.96)	
Total complication rate			
\leq 5%	63.09 \pm 15.63	65.93 (38.94–91.15)	0.500*
>5%	66.43 \pm 12.51	66.37 (43.36–86.73)	

* Student t-test.

† Mann-Whitney U-test.

‡ Kruskal-Wallis H-test.

consent form and American Society of Anesthesiologists Physical Status class in the preoperative evaluation; fasting solid food and last liquid food times before surgery during the preoperative nursing consultation; surgery time, urine catheter, and antibiotic prophylaxis during the operating room nursing evaluation; timing and type of anesthesia, liquid loading and blood product transfusion in anesthesia management; duraplasty and skin suture in surgical manipulations; postoperative CT and analgesia in postoperative management; extubation time in postoperative nursing management; and mental status at the discharge evaluation and first follow-up visit.

Conclusions

The findings of our study reveal that accredited clinics apply preoperative protocols more strictly and that the

postoperative hospital LOS is shorter in departments with a high compliance rate to intraoperative protocols. Providing international standardization in ERAS protocols with new prospective randomized trials will improve patient care and health systems.

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The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Yakar, Egemen, Civlan, Töngge, Coşkun. Acquisition of data: Elbir, Hanalioğlu, Civlan, Töngge. Analysis and interpretation of data: Yakar, Bakırarar, Hanalioğlu. Critically revising the article: Bakırarar, Egemen, Hanalioğlu, Civlan, Töngge, Coşkun, Türkoğlu. Reviewed submitted version of manuscript: Yakar, Bakırarar, Egemen, Hanalioğlu, Civlan, Coşkun. Approved the final version of the manuscript on behalf of all authors: Yakar. Statistical analysis: Bakırarar. Administrative/technical/material support: Albuz, Türkoğlu. Study supervision: Yakar, Egemen, Dere, Coşkun, Türkoğlu.

Supplemental Information

Online-Only Content

Supplemental material is available online.

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