World J Surg (2018) 42:2269–2276
https://doi.org/10.1007/s00268-017-4445-1

ORIGINAL SCIENTIFIC REPORT

Characteristics, Stratification and Time to Death in a Population-Based Cohort of Patients with Ruptured Abdominal Aortic Aneurysms Not Undergoing Surgery

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Published online: 30 December 2017

Abstract

Background The available literature on ruptured abdominal aortic aneurysms (rAAA) centers on survival after operation and commonly, reasons why some patients do not undergo surgery are not addressed. The aim of the present study is to examine, in a population-based cohort, the characteristics, stratification and time to death of patients admitted to hospital, but not undergoing operation for rAAA.

Methods A retrospective, single-center study. All patients admitted to Stavanger University Hospital from the primary catchment area with rAAA on admission or in-hospital from 2000 to 2014 were included.

Results Altogether 214 patients with rAAA were identified; 57 (27%) patients did not undergo surgery. The proportion of women was significantly higher (37 vs. 14%; $p < .001$) in patients not having surgery. The reasons for not undergoing operation were patient 'not fit for surgery' (30%), 'dying or agonal' at time of diagnosis (26%), 'did not want operation' (21%) and 'diagnosed at autopsy' (23%). Of the non-operated patients, 45 had rAAA on arrival to hospital, 12 had in-hospital rupture and 21 patients had previously been diagnosed with an abdominal aortic aneurysm. Non-operative treatment was uniformly fatal. The 45 patients with rAAA on arrival were scored using four scoring systems, the predicted mortality varied widely, and the median time from admission to death was 7.4 h (range 0–1337).

Conclusion In about half of patients, a decision not to operate was made by the consultant vascular surgeon or the patient. In the subgroup of patients not diagnosed until autopsy or having an in-hospital rupture, an earlier diagnosis might have altered the outcome.

Introduction

Ruptured abdominal aortic aneurysm (rAAA) is a challenging emergency with overall high mortality rates. Some small series report an operative mortality of 10% or lower after endovascular aneurysm repair (rEVAR) of rAAA, but such remarkably low mortality has not been replicated in larger series [1].

Mortality in rAAA depends on several factors, including hospital referral patterns, patient selection and health care systems. Further, patients with rAAA die in different settings: before arriving to hospital, in the perioperative setting, some are turned down for surgery and some decline

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surgery despite being informed of the grave prognosis. Thus, understanding the background and reason why not all patients with rAAA undergo operation is of importance for further enlightening the differences in actual resection rates, mortality and differences in outcomes.

In the current literature, there is a surprising paucity of available information on the cohorts of patients with rAAA that did not undergo operation. Population-based papers published since the turn of the century invariably report overall mortality in excess of 70% partially explained by the not insubstantial number (from 9 to 50%) of patients with rAAA that are not treated surgically [2–4].

Consequently, the aim of this paper is to examine, in a population-based setting, the characteristics, stratification and time to death of patients with rAAA that did not have surgery.

Methods

The study was approved by the Regional Committee for Medical and Health Research Ethics North (REK Nord 2011/918) and as the study design was observational and retrospective, it was exempt from formal requirements regarding informed consent from the included patients.

Study population

Stavanger University Hospital (SUH) is the only hospital in the southern part of Rogaland County, Norway. SUH has a primary catchment population of about 360,000. The epidemiology of rAAA in this region has been reported previously [3]. In the present cohort study, we included all patients from the primary catchment area of SUH that were admitted with rAAA or that ruptured during the hospital stay, focusing on patients not having rAAA repair in the period from January 2000 to December 2014. The reporting of this study conforms to the STROBE statement [5].

Definition and inclusion criteria

All patients with a primary ruptured infrarenal or juxtarenal aneurysm were assessed for inclusion in the study. Secondary aneurysms (aneurysm after previous repair of aortic aneurysm or atherosclerosis), thoracoabdominal aneurysms or isolated iliacal aneurysms were excluded [3]. Patients from outside the primary catchment area that were transported to SUH were not included in the study.

The definition of rAAA was based on finding a periaortic hematoma on operation or autopsy or extravasation of blood on computed tomography (CT). Patients with a large abdominal aortic aneurysm (AAA) on ultrasound and acute symptoms of abdominal pain and shock who died were also considered to have rAAA when no other immediately likely diagnosis was present.

Patients were retrospectively identified by searching the electronic patient record database and Systematized Nomenclature of Medicine codes in the pathology and autopsy records. The electronic patient records database was searched using the International Classification of diseases, code I71.3, and all adjoining codes in order not to miss incorrectly coded cases. The autopsy archive was searched for all autopsies coded with topography T42000 (‘aorta’) or T41000 (‘artery NOS’). During the study period, the rate of autopsy of in-hospital deaths fell from 28 to 19%.

Scoring systems

Four scoring systems were utilized in retrospect to predict a possible postoperative outcome in the patients: the Vancouver score [6] (VS; loss of consciousness, cardiac arrest, age), the updated Glasgow Aneurysm Score [7] (GAS; open surgery, age, shock, myocardial disease, cerebrovascular disease, renal insufficiency), the Edinburgh Ruptured Aneurysm Score [8] (ERAS; hemoglobin level, systolic blood pressure, Glasgow Coma Scale Score) and the Hardman index [9] (HI; age, creatinine level, loss of consciousness, hemoglobin level, electrocardiographic ischemia). The scores are calculated from the variables and presented as expected postoperative mortality.

Statistical analysis

Statistical Package for Social Sciences (SPSS v. 24; IBM™, Armonk, NY, USA) was used for statistical analysis. In univariate analysis, the Kruskal–Wallis test was used for continuous variables and the χ^2 test or Fisher exact test was used to test for differences in categorical variables.

A Kaplan–Meier curve was used to present survival time.

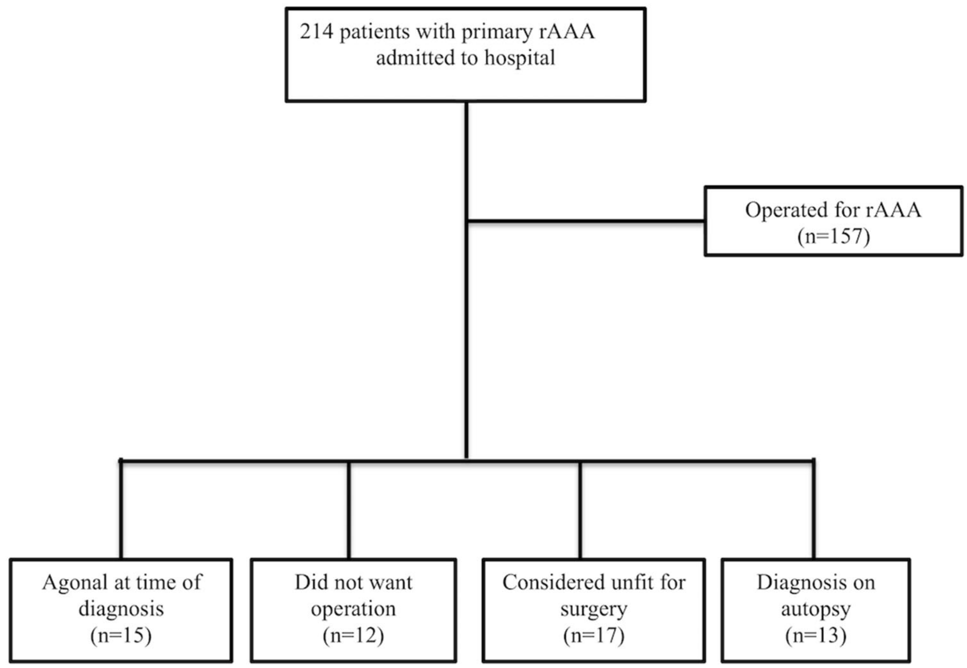
All statistical tests are two-tailed, and statistical significance was set for p values <.050.

Results

Patient characteristics

Altogether 214 patients (Fig. 1) from the hospital’s primary catchment area were admitted and diagnosed on admission, in-hospital or postmortem to have a rAAA. Altogether, 157 patients had an operation (135 men and 22 women) for rAAA with a 30-day mortality of 45% (71 of 157 patients). rEVAR was performed in one case; the rest

Fig. 1 Patient population



had an open operation. In a comparison between non-operated and operated patients (Table 1), the women and men not having surgery were significantly older. The sex distribution was not the same between non-operated and operated patients, with significantly higher proportion of women in the non-operated group ($p < .001$). Furthermore, patients not having surgery were more likely to have a cardiac arrest, loss of consciousness and a lower hemoglobin and higher creatinine.

The 57 patients (27%) that did not undergo surgery for rAAA were stratified into four groups according to why they did not have an operation: agonal at time of diagnosis, denied surgery on the grounds that they were considered unfit for surgery or the patients themselves declined surgery or were diagnosed on autopsy (Fig. 1). The characteristics and parameters registered on admission are listed in Table 2. The age distribution for men was not the same across the groups, but no significant differences were demonstrated for females. Women (21 of 57 patients; 37%) were significantly older than men ($p = .007$), but in comparisons between age and sex in the different subgroups a significant difference was only found for the autopsy group ($p = .045$).

Table 1 A comparison between patients having and not having operation for rAAA

	Not operated $N = 57$	Operation $N = 157$	p
Age (females)	88 (74–99)	84 (62–93)	.011
Age (males)	85 (65–93)	77 (45–91)	<.001
Sex			
F	21	22	<.001
M	36	135	<.001
Cardiac arrest	14 (25)	7 (4)	<.001
Cardiac disease	30 (53)	71 (45)	.35
Cerebrovascular disease	14 (25)	20 (13)	.038
Loss of consciousness	19 (33)	17 (11)	<.001
Hemoglobin (g/dL)	9.6 (4.3–16.3)	11.3 (2.6–19.2)	.003
Systolic blood pressure (mmHg)	90 (0–240)	91 (0–220)	.26
Creatinine (μmol/L)	127 (42–527)	116 (53–500)	.038

Data from the emergency room. Median (range) for continuous variables, counts (%) for categorical variables

Table 2 Patient characteristics, data from the emergency room

	Agonal $n = 15$	Unfit $n = 17$	Declined $N = 12$	Autopsy $n = 13$	p
Age					
Women	88 (74–92)	89 (88–99)	88 (86–96)	88 (82–97)	.061
Men	77 (66–89)	86 (76–90)	89 (77–93)	79 (65–88)	<.001
Gender					
Women	6	5	5	5	.006
Men	9	12	7	8	
Cardiac arrest	11 (73)	0 (0)	0 (0)	3 (23)	<.001
Cardiac disease	7 (47)	9 (53)	4 (33)	10 (67)	.166
Cerebrovascular disease	3 (20)	2 (12)	4 (33)	5 (38)	.318
Loss of consciousness	13 (87)	1 (6)	1 (8)	4 (31)	<.001
Hemoglobin (g/dL)	9.1 (4.3–16.3)	9.2 (6.1–15.2)	10.7 (5.5–12.6)	12.7 (6.9–15.6)	.244
Systolic blood pressure (mmHg)	50 (0–130)	110 (45–170)	108 (0–178)	103 (0–240)	.008
Creatinine (μmol/L)	111 (42–227)	132 (71–428)	128 (84–527)	146 (75–521)	.579
Aneurysm (size, mm)	64 (50–120)	70 (46–118)	84 (56–105)	NA	.241

Median (range) for continuous variables, counts (%) for categorical variables

Patients with intact aneurysm on admission

Twelve of the 57 patients were considered to have an in-hospital rupture. Five patients had abdominal pain but no rupture on CT on admission, including one patient that was considered to have an impending rupture and died on way to theater. Five patients were admitted without any abdominal or back pain but for other reasons: pneumonia ($n = 2$), metastatic urinary cancer ($n = 2$) and haemoptysis and subsequently developed symptoms of rAAA and were diagnosed 5, 6, 5, 13 and 10 days after admission. Two patients were diagnosed on autopsy: one patient was admitted with abdominal pain and was investigated for possible gastrointestinal cancer but collapsed 5 days after admission; the other was admitted with cerebellar bleeding and died suddenly 7 days after admission.

Agonal patients

The 15 patients that were considered agonal at the time of diagnosis had a significantly higher occurrence of cardiac arrest, loss of consciousness and a lower systolic blood pressure when compared to the other three groups. Eight patients were admitted with on-going cardiopulmonary resuscitation and were diagnosed with rAAA by ultrasound in the ER; another three had a cardiac arrest in the ER or on the way to the theater ($n = 2$). In the remaining two patients, AAA or rAAA was not suspected on admission, but their condition deteriorated after 1 and 2 days in hospital. At the time of diagnosis, both patients were unconscious and hypotensive.

Patients that declined or were denied operation

Altogether, 21 of 57 patients (37%) had previously been diagnosed with AAA, but elective surgery had not been planned as eight did not want an operation, eight were considered to be unfit for surgery, three had not been assessed by a vascular surgeon, and two had a no-show at the outpatient clinic.

After admission, a total of 17 of 57 (30%) patients were considered unfit for surgery at the time of diagnosis and ten of these patients had a known AAA. The reasons as stated in the patient's notes as to why they were considered unfit for operation are listed in Table 3. Age was a determinant in most patients and is not included in the Table except for the one patient where it was the only registered factor. An elective endovascular aneurysm repair (EVAR) program was commenced in 2006, and after 2008 only two patients with rAAA have been considered unfit for surgery, although the difference is not significant [8 (5%) of 147 patients in the early period to 2 (3%) of 67 in the late period] ($p = .728$).

Twelve of 57 patients (21%) declined surgery. Generally, the notes fail to give a satisfactory answer as to why.

Diagnosis on autopsy

Finally, 13 patients were diagnosed on autopsy, including three patients that had a cardiac arrest prior to arrival in hospital and were admitted with on-going CPR and another three that died shortly after arrival. Six of the remaining seven patients were admitted with abdominal or back pain and a preliminary diagnosis of cerebral insult, bowel

Table 3 Patients considered unfit for operation

Gender	Age	Known AAA	Comorbidity
M	77	No	Dementia
M	80	Yes	Coronary disease, residing in nursing home
M	81	Yes	Chronic obstructive lung disease
M	83	Yes	Metastatic bladder and prostate cancer
M	85	No	Cerebral insult, renal failure, pneumonia
M	86	No	Aortic valve disease
M	87	Yes	Heart failure, renal failure
F	88	Yes	Aortic valve disease, coronary disease
F	89	No	Aortic valve stenosis, pneumonia, deliria
F	89	Yes	Heart failure
M	89	No	Aortic valve stenosis, coronary disease
M	90	Yes	Lung and bladder cancer
M	90	Yes	Renal failure
M	90	No	Dementia
M	90	Yes	Renal failure
F	92	Yes	Coronary heart disease
F	99	No	Age

Reasons for turndown for surgery

obstruction (2 patients), gastrointestinal cancer, hypertension or coronary disease. One patient was admitted with unrelated disease (cerebellar bleeding) and died 7 days after admission. The patients that were diagnosed on autopsy were evenly distributed throughout the 15-year study period.

Scoring systems

The 45 patients with rAAA on arrival to hospital were scored with the VS, GAS, ERAS and HI scores. VS score could be calculated for all patients, but for the other scores data were missing: Gas 9, ERAS 8 and HI 14. Figure 2 shows the scores for each patient.

Time to death

Non-operative treatment was uniformly fatal. The median time from arrival in hospital to death was 7.4 h (range 0–1337) in the 45 patients with rAAA on arrival (Figs. 3 and 4) and 152 h (range 3.7–1920) in the 12 patients considered to have a rupture after admission. Two patients had a long-term survival after discharge to nursing home (55 and 80 days), CT confirmed rupture in one case, whereas the other was diagnosed on the presence of a large, but intact aneurysm on CT on admission (11 cm) and developed symptoms compatible with rAAA the following day: abdominal pain, hypotension (100/60) and a fall in Hb from 12.5 to 7.5 g/dL.

Discussion

In the current study from a defined population presenting to a single hospital, 27% (57 of 214) of patients with rAAA did not have an operation. Patients not undergoing surgery were stratified into four groups: 'not fit for surgery' (30%) followed by 'agonal at time of diagnosis' (26%), 'did not want operation' (21%) and 'diagnosed at autopsy' (23%). Thus, in half of the patients not undergoing surgery a definite decision not to operate was based on physician- or patient-led arguments. One may argue that agonal patients ($n = 15$) ought to be included in the group of patients considered unfit for surgery, but this group included 8 patients that were admitted with on-going CPR, another 5 had a cardiac arrest shortly after arrival, and the remaining two were moribund with loss of consciousness and grave hypotension at the time of diagnosis (in-hospital rupture). Survival after preoperative cardiac arrest in rAAA is known to be dismal [6, 10]. The policy at SUH is to not offer surgery in patients with cardiac arrest or interfacility transfer in patients with cardiac arrest or loss of consciousness [11].

The non-operative rate of 27% is remarkably similar to another contemporary study that reported a non-operation rate of 30% [12]. Considerably higher turn down rates (41%) were detailed in a recent UK paper based on an administrative dataset [13]. Only 2 (3%) of 57 non-operated patients had a failed surveillance of a known AAA, in contrast to another Scandinavian study where 31% of non-operated patients had failed surveillance [12]. Patients

Fig. 2 Expected mortality, scoring systems. Patients 1–12 agonal, 13–21 did not want operation, 22–34 unfit for surgery, 35–45 diagnosis on autopsy

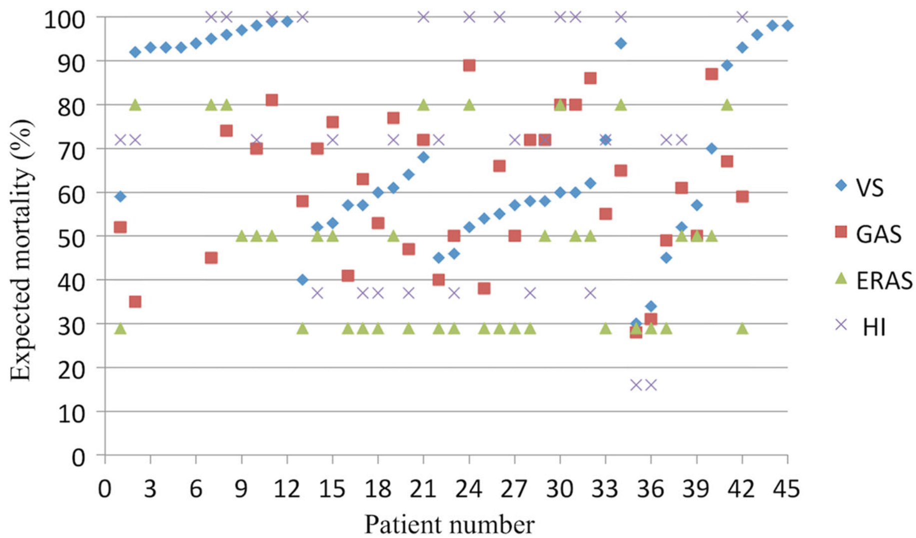
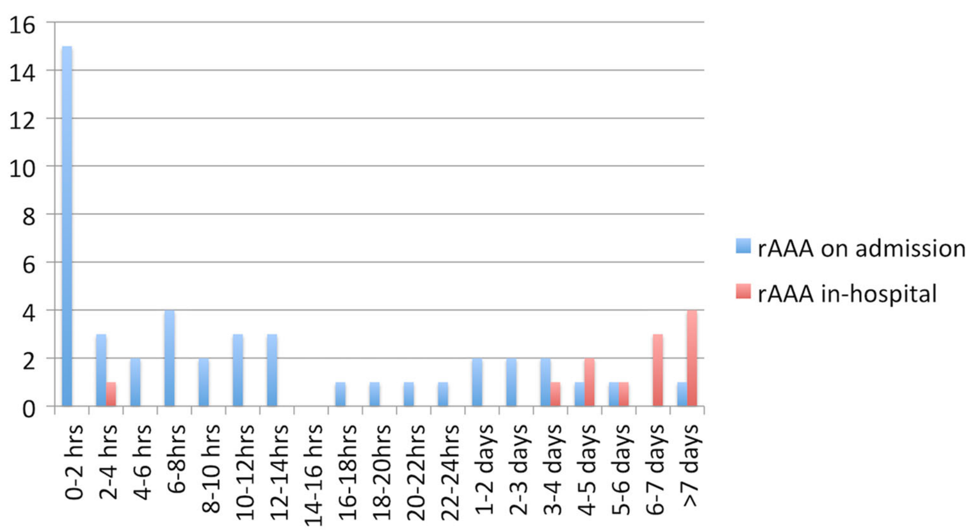


Fig. 3 Time from admission to death, hours or days in patients with rAAA on admission ($n = 45$) or in hospital ($n = 12$)



under surveillance at SUH visit the outpatient clinic regularly for ultrasound scan and consultation; the interval is decided by the size of the aneurysm. Screening for AAA has not been implemented nationwide in Norway.

Most papers reporting survival in rAAA fail to report the ratio of patients not having surgery [2]. Not reporting data on patients that did not receive corrective treatment may inflate the actual numbers of survivors and, may in part, explain the reported variation in outcomes between studies on outcome for rAAA.

The proportion of women was significantly higher ($p < .001$) in patients not having corrective treatment. It is known from previous trials that women have higher mortality than men following open repair in elective AAA and rAAA [14].

Interestingly, in the current study the number of patients considered unfit for surgery has fallen since 2008. An EVAR program for elective cases was started in 2006 and may explain the reduction in patients with previously diagnosed AAA being turned down for surgery when presenting with rAAA. rEVAR has been regularly performed at our institution the two last years and shows promise of further reducing the number of patients considered unfit for surgery [15, 16]. Patients previously considered unfit for elective repair were reassessed when presenting with rAAA.

No general consensus exists on how to assess if a patient with rAAA is unfit for surgery. The wide variation in predicted mortality and missing data hampers the applicability of scorings systems. A patient with loss of consciousness and cardiac arrest will have a high risk of death,

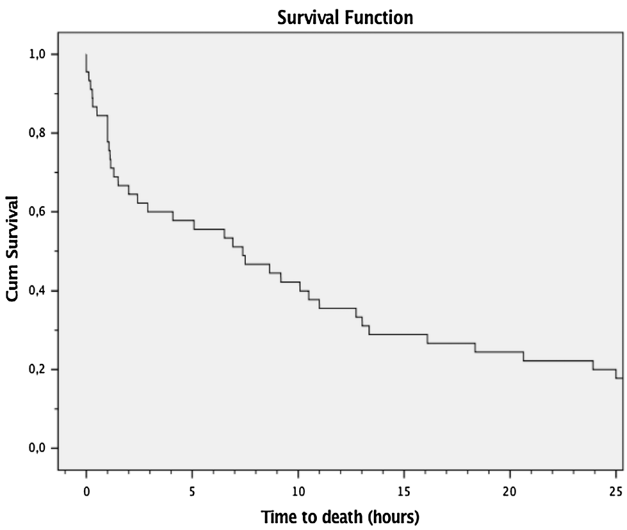


Fig. 4 Survival curve in patients ($n = 45$) with rAAA on admission

but you do not need a score to tell you that. The available prognostic scores generally have a poor accuracy [17].

Some patients declined surgery (12 of 57 non-operated, 21%). The notes did not give a satisfactory explanation why. Ethical considerations must be addressed in such instances, including an assessment of whether the patient is capable of making an informed refusal and without any coercion [18]. Patients who had previously declined elective repair were still free to elect emergent repair upon presentation with rupture.

Not all patients are diagnosed pre-mortem and with falling autopsy rate one may theorize that a substantial number of patients are never diagnosed with rAAA [19]. The other studies that address the fate of patients not operated for rAAA make no mentioning of patients with in-hospital rAAA. It seems safe to assume that in our material half of the patients with in-hospital rupture (6 of 12) were admitted with a symptomatic aneurysm (abdominal pain) and that expediency in diagnosis might have altered the outcome [20].

Approximately 1/5 of patients admitted with rAAA were dead in less than 2 h, half the patients were dead within 8 h, and 1/5 of patients survived the first 24 h. The findings emphasize the need for rapid assessment and diagnosis [19, 21].

The study size is the major limitation of the study, but the few studies detailing this group of patients have a similar or smaller study size [4, 21, 22]. We believe that the findings contribute substantially to the existing knowledge regarding why not all patients with rAAA undergo surgery.

Conclusion

No consensus exists on whom to offer surgery, and there is a lack of objective criteria for when to turn down surgery in rAAA. Surgeon experience and preference may be the only basis for judgment in some cases. In other instances, the patient's expressed will takes priority and is thus an ethical guidance for decision-making.

Compliance with ethical standards

Conflict of interest No conflicts of interest for any of the authors.

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