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RESEARCH

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# Prevalence of aortic aneurysmal sac expansion using CTA in type II endoleak: comparison between endoleak visualization in CTA phase and in delayed phase

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## Abstract

**Background** To compare the prevalence of aneurysmal sac expansion in type II endoleak (T2E) presenting on CTA phase with T2E presenting on delayed phase.

**Methods** A retrospective study at a single tertiary care center in Bangkok, Thailand. Serial measurement of aneurysmal sac diameters was obtained and the prevalence of aneurysmal sac expansion was compared**.**

**Results** 130 patients were enrolled from January 2005 to December 2019. The prevalence of aneurysmal sac expansion in T2E patients presenting in the CTA phase and delayed phase in this 2-year observational study were 16% and 0%, respectively ($P=0.065$). Age > 80 years (25.8% vs. 8.8%; $P=0.028$) and initial aneurysmal sac diameter (71.3 mm vs. 57.7 mm; $P=0.035$) were associated with the aneurysmal sac expansion. Aneurysmal sac expansion occurred in 18.3% of patients with patent IMA and 6% of patients with occluded IMA ($P=0.053$). The number and diameter of lumbar artery feeder, and the presence of intrastent thrombus were not associated with aneurysmal sac expansion. T2E presenting on CTA phase resolved in 9.2% of cases compared with 7.14% of delayed phase cases ($P=1.0$).

**Conclusions** The prevalence of aneurysmal sac expansion in T2E patients presenting on CTA phase was not statistically significantly higher than in patients on delayed phase. Age more than 80 years and initial aneurysmal sac diameter were significantly associated with aneurysmal sac expansion.

**Keywords** Type II endoleak, CTA, EVAR, Aneurysmal sac expansion

## Background

Endovascular aortic aneurysmal repair (EVAR) has been proven to be an effective treatment in patients with abdominal aortic aneurysm (AAA) with suitable anatomy. Patients treated with EVAR have significantly less operative morbidity and mortality than those treated with conventional open surgery [1, 2]. Type II endoleak (T2E) is the most common type occuring in 10–25% of EVAR patients [3, 4]. It occurs when retrograde blood flows via aortic branches e.g., inferior mesenteric artery, lumbar artery, accessory renal artery, median sacral artery. Most patients with T2E spontaneously resolve within 6 months; referred to as transient T2E [5]. However, approximately 20% of patients have persistent T2E [5]. In patients with persistent endoleak, an increased rate of aneurysmal sac expansion and re-intervention has been reported [5], and the prevalence of adverse outcomes, including aneurysmal sac expansion or re-intervention, is as high as 55% [6] leading to AAA-related

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mortality [7]. In patients with T2E, the prevalence of aneurysmal sac rupture is nearly 1% [4, 6].

Current treatment guidelines recommend postoperative surveillance CT scan at 1, 6 and 12 months, and annually thereafter to prevent late rupture and aneurysm-related mortality [8]. Several investigators have used a combination of unenhanced CT, CTA, and delayed phases for post-EVAR evaluation and detection of endoleak [9, 10]. This protocol leads to increased radiation exposure [11, 12]. The total effective radiation dose may be as high as 145–205 mSv over a 5-year follow-up period which increases lifetime attributable cancer risk [12]. Elimination of one phase from routine 3-phase scan may reduce total effective radiation dose if feasible. Iezzi et al. [13] reported that delayed phase imaging did not increase sensitivity to detect endoleak and Hong et al. [14] reported that a small number of patients with endoleak only on delayed phase of CT had resolved spontaneously.

This study aims to determine the prevalence of aortic aneurysmal sac expansion using CTA to compare T2E patients where the endoleak presented in the CTA phase with patients with retrograde flow presenting in the delayed phase of CT. We hypothesized that if T2E found only on the delayed phase is not clinically significant, we could eliminate delayed phase CT to reduce radiation exposure in post-EVAR patients.

## Methods

### Patients

This study was approved by the Institutional Review Board. The study retrospectively reviewed the medical records and CT images from the picture archiving and communication system (PACS) of patients diagnosed with T2E in a single, tertiary care hospital in Bangkok, Thailand. Electronic medical record review was performed for patient ages, sex, date of EVAR, and date of aneurysmal sac expansion, rupture or embolization, which was the primary clinical endpoint. Informed consent was exempted due to the retrospective nature of the study. Patients were included if they had been diagnosed with T2E from January 2005 to December 2019 and had received CTA of the abdominal aorta at least two times within the 24 months after EVAR. Patients were excluded if they had other types of endoleak, developed graft infection, migration, or kinking, or if they underwent embolization or surgery due to reasons other than aneurysmal sac expansion.

### CTA technique

CTA was performed using three types of scanners (Somatom Definition dual source CT; Siemens, Forchheim, Germany; Discovery CT 750HD; GE Healthcare, Milwaukee, USA or Revolution CT, GE Healthcare, Milwaukee, USA). Two CTA abdominal aorta protocols for post-EVAR evaluation are used in our hospital**.** The first protocol is conventional CTA consisting of three phase scanning; unenhanced CT, CTA phase and delayed phase. The second is dual-energy protocol with CTA phase and delayed phase and virtual unenhanced CT reconstruction. 100 ml of nonionic iodinated contrast media (Iopamidol, Iopamiro, Bracco) was administered into an antecubital vein using power injector at a flow rate 4 mL/s. CTA in both protocols were obtained using the bolus-tracking technique with a threshold of 150 Hounsfield units (HUs) at the abdominal aorta proximal to the endovascular stent graft. Delayed phase was done 120 s after intravenous injection. The 1.25 mm slice thickness images were used for interpretation.

### Imaging interpretation

All imaging studies were categorized according to the follow-up period in which they were performed; 1–3 months, 3–12 months, and 12–24 months after the date of EVAR. Two radiologists experienced in cardiovascular diagnostic imaging independently reviewed all the studies to determine the presence of T2E in the CTA phase or in the delayed phase. After multiplanar reconstruction, the aneurysmal sac diameter was measured using an electronic caliper. The number and diameter of each lumbar artery feeder, patency of interior mesenteric artery, thrombus thickness within stent graft, and the ratio between thrombus thickness and maximal aneurysmal sac diameter were recorded. Aneurysmal sac expansion is defined as an expansion of more than 5 mm during the period of follow-up. To measure the prevalence of aneurysmal sac expansion, an analysis of the last imaging study for each patient was performed.

### Statistical analysis

The data were reported as mean and standard deviation for continuous variables and number and percentage for categorical variables. Univariate analysis was performed using the Chi-square test, Fisher's Exact Test**,** t-test, or Mann–Whitney U test to compare factors associated with aneurysmal sac expansion. Multivariate analysis using logistic regression was performed to identify factors independently related to aneurysmal sac expansion. Analyses were performed using SPSS Statistics software (SPSS, Inc., Chicago, IL, USA). A $P$-value < 0.05 was considered statistically significant.

## Results

One hundred and thirty-nine patients (115 men, 24 women) with a mean age of 74.8 years; range, 55–94 years) were included in the study. During the 2nd

**Table 1** During 2nd period follow up at 3–12 months after EVAR (mean follow up date 9.2 months, SD 2.74 months)

| *n* = 130 | Total | Sac expansion | No sac expansion |
|---|---|---|---|
| Present on CTA phase | 103 | *n* = 4 (3.9%) | 99 (96.1%) |
| Present only delayed phase | 13 | *n* = 0 (0%) | 13 (100%) |
| No endoleak | 14 | 0 (0%) | 14 (100%) |

follow-up period at 3–12 months (Table 1), there were 130 patients and 103 showed an endoleak on the CTA phase (Fig. 1), 13 patients had an endoleak on the delayed phase (Fig. 2), and 14 did not have an endoleak. Four patients (3.9%) who had an endoleak on CTA phase had aneurysmal sac expansion (Fig. 3) and no patient with an endoleak on the delayed phase had sac expansion.

During the 3rd period of follow-up at 12–24 months (Table 2), there was an increased number of patients manifesting endoleak on only the delayed phase. Of 104 patients, 66 had an endoleak on CTA phase, 19 demonstrated endoleak on the delayed phase, and 19 did not have an endoleak. Nine patients (13.6%) who had an

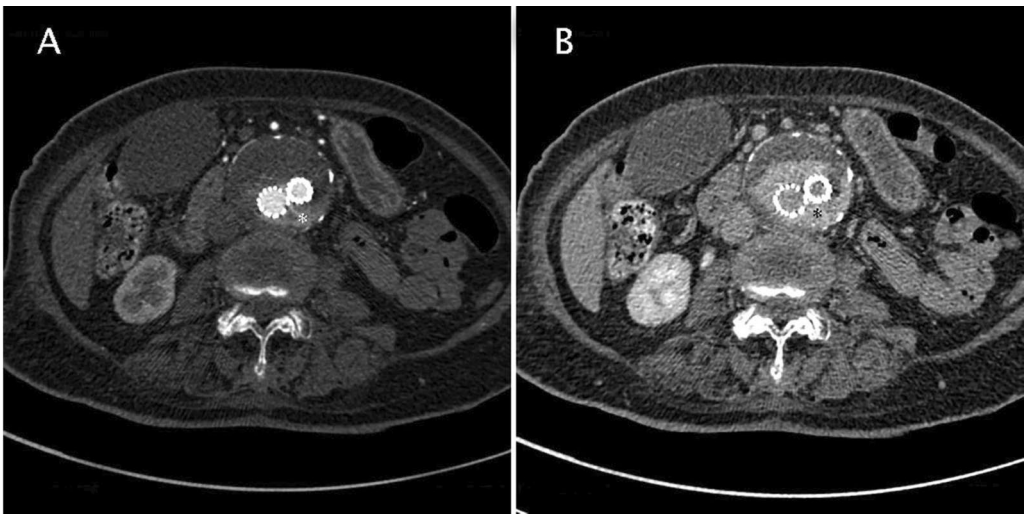


**Fig. 1** An 86-year-old woman underwent conventional CTA abdominal aorta one month after EVAR and was diagnosed with T2E Image **A**. CTA phase, evidence of contrast accumulation within aneurysmal sac (white asterisk) Image **B**. Delayed phase, accumulation of contrast accumulation in the aneurysmal sac (black asterisk)

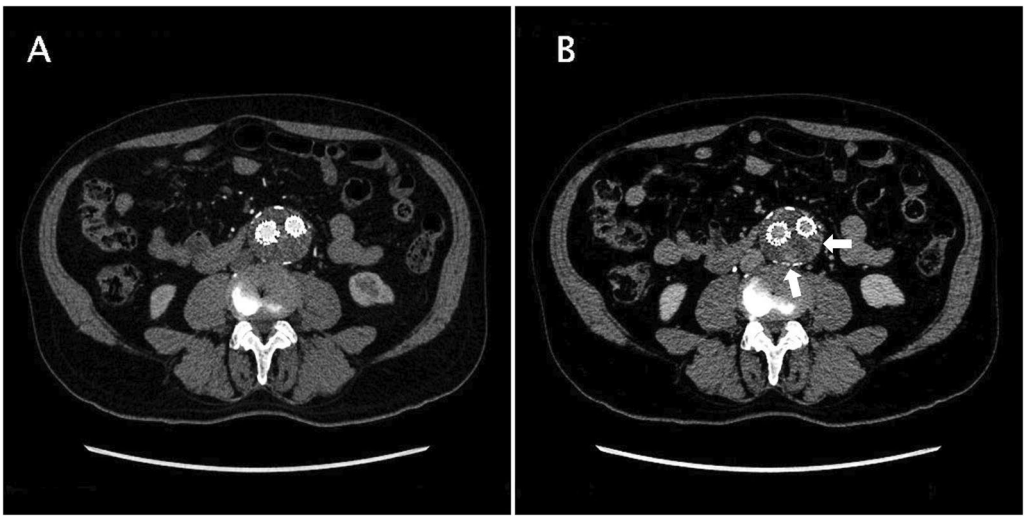


**Fig. 2** A 70-year-old man underwent conventional CTA of the abdominal aorta after 18 months following EVAR. Image **A**. CTA phase, no evidence of contrast in aneurysmal sac Image **B**. Delayed phase, evidence of faint contrast accumulation within the aneurysmal sac due to T2E, fed by the left lumbar artery (white arrow)

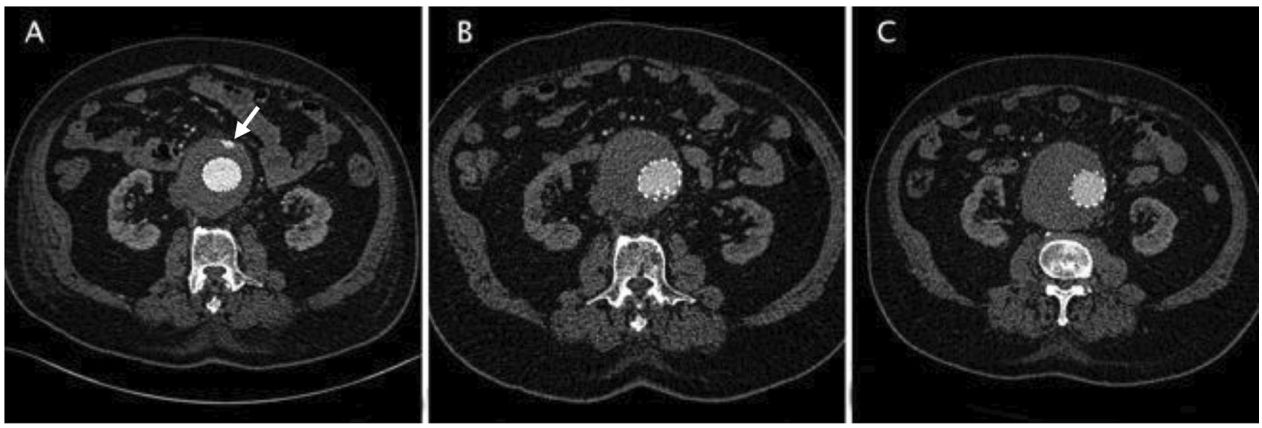


**Fig. 3** A 74-year-old man developed sac expansion (> 5mm) during the period of follow up. Image **A**: CTA abdominal aorta 7-days after EVAR, the aneurysmal sac which was fed by inferior mesenteric artery (white arrow) was 70.9 mm diameter, consistent with the diagnosis of T2E. Image **B**: Follow-up at 10 months after EVAR, the aneurysmal sac was 73.6 mm diameter. Image **C**: Follow-up 18 months after EVAR, the aneurysmal sac was 78.6 mm diameter

**Table 2** During 3rd period follow up at 12–24 months after EVAR (mean 18.5 months, SD 5.0 months)

| ***n*** **= 104** | **Total** | **Sac expansion** | **No sac expansion** |
|---|---|---|---|
| Present on CTA phase | 66 | *n* = 9 (13.6%) | 57 (86.4%) |
| Present only delayed phase | 19 | *n* = 0 (0%) | 19 (100%) |
| No endoleak | 19 | *n* = 0 (0%) | 19 (100%) |

**Table 3** Relationship between the presence of T2E on CTA phase or only delayed phase and sac expansion during last period follow-up

| ***n*** **= 95** | **Total** | **Sac expansion** | **No sac expansion** |
|---|---|---|---|
| Present on CTA phase | 75 | 12 (16%) | 63 (84%) |
| Present only delayed phase | 20 | 0 (0%) | 20 (100%) |

endoleak on the CTA phase had aneurysmal sac expansion while none of the patients with an endoleak on the delayed phase had sac expansion.

The data from the last imaging study of each patient are summarized in Table 3. If the 3rd period imaging study was not available, the data from the 2nd period examination was analyzed instead. Among the 95 patients examined, 75 had an endoleak on the CTA phase and 20 had an endoleak only on the delayed phase. Twelve patients (16%) who had endoleak on the CTA phase had aneurysmal sac expansion and no patient with endoleak on the delayed phase had sac expansion (16% vs. 0%; $P = 0.065$).

Patients aged more than 80 years were significantly more likely to have sac expansion (25.8% vs. 8.8%, $P$ value = 0.028). Patients with a larger initial maximal aneurysmal sac diameter were more likely to experience aneurysmal sac (71.3 mm vs. 57.7 mm, $P = 0.035$) (Table 4). The prevalence of T2E resolution on the 3rd follow-up period was not statistically significantly different between the CTA group (9.2%) and the delayed group (7.1%) ($P = 1.0$).

## Discussion

Several studies have described the factors that predict aneurysmal sac expansion greater than 5 mm in T2E including; (1) the number and diameter of the patent lumbar artery, (2) patency of the inferior mesenteric artery, (3) the thickness of the thrombus within the aneurysmal sac, (4) the ratio between the maximal aneurysmal sac diameter and the thickness of the thrombus in the aneurysmal sac and, (5) the patient is more than 80 years of age [3, 15–18] However, there is limited information on the association between the presence of an endoleak during the CTA phase and sac expansion. We observed that in the 3–12 months following EVAR, the prevalence of sac expansion on the CTA phase was 3.88% and 0% in the delayed phase, and in the 12–24 months following EVAR it was 13.6% vs. 0%. Although there were 20 patients who had endoleak only in the delayed phase, this result suggests that patients with T2E on the CTA phase develop sac expansion more often. In the 3rd follow-up period, the difference in the prevalence of sac expansion was large (16% vs. 0%) but was not statistically significant ($P = 0.065$). This could be due to the small number of the patients with T2E on the CTA phase that later developed sac expansion ($n = 12$) compared with the delayed phase

**Table 4** Relationship between patient characteristic and sac expansion

| Variable | Aneurysmal sac diameter enlargement | | *P* value |
|---|---|---|---|
| | Enlargement ($n=16$) | No enlargement ($n=105$) | |
| Age | | | 0.028 |
| Age ≥ 80 years | 8 (25.8%) | 23 (74.2%) | |
| Age < 80 years | 8 (8.9%) | 82 (91.1%) | |
| Sex | | | 0.736 |
| Male | 14 (14%) | 86 (86%) | |
| Female | 2 (9.5%) | 19 (90.5%) | |
| Patency of inferior mesenteric artery | | | 0.059 |
| Patent | 13 (18.3%) | 58 (81.7%) | |
| Occlude | 3 (6%) | 47 (94%) | |
| Intrastent thrombus | | | 1.00 |
| Presence | 0 (0%) | 5 (100%) | |
| Absence | 16 (13.8%) | 100 (86.2%) | |
| Presence of lumbar artery feeder | | | 0.698 |
| Presence | 13 (12.5%) | 91 (87.5%) | |
| Absence | 3 (17.6%) | 14 (82.4%) | |
| Initial sac diameter (mm) | 71.3 ± 23.1 | 57.7 ± 12.4 | 0.035 |

($n=0$). A larger sample size and a longer period of follow-up may enable us to arrive at a conclusive result.

We found that age > 80 years and the initial size of the aneurysmal sac were significant risk factors for aneurysmal sac expansion ($P<0.05$), a finding that is consistent with that reported in a meta-analysis by Guo et al. [3]. Aneurysmal sac expansion occurred in 18.3% of patients with patent IMA and 6% of patients with occluded IMA ($P=0.053$). The number of patent lumbar artery and the maximal diameter of the lumbar artery were not statistically significant in contrast to reports by Otsu et al. [17] and Löwenthal et al. [18]. However, these studies attempted to predict anatomical risk factors before EVAR while we studied the time after EVAR. Several articles have reported varying associations between intrastent thrombus and persistent T2E. Studies by Sampaio et al. [19] and Abularrage et al. [19] found intrastent thrombus to be a protective factor, whereas articles by AbuRahma et al. [20] and Ward et al. [21] did not confirm an association. A study by Otsu et al. found it to be a significant protective factor for persistent T2E [17]. However, none of these studies reported an association between intrastent thrombus and aneurysmal sac expansion. We found no connection between intrastent thrombus and aneurysmal sac expansion ($P=1.00$).

Iezzi et al. [13] described four of 36 cases of T2E detected on the delayed phase but not visualized on the CTA phase that were stable or decreased in size during the follow-up period. Hong et al. [14] reported on five cases of T2E visualized on only the delayed phase (from 32 cases of T2E) that spontaneously disappeared. These findings are consistent with our results in that no patient with T2E on the delayed phase developed sac expansion. These findings suggest that delayed phase imaging may be avoided in patients showing T2E only in the delayed phase.

## Limitations and recommendations

Although ours is the largest series of patients with T2E detected in the delayed phase and monitored for up to 24 months, our small sample size prevents us from concluding that delayed phase CT is unnecessary. Eliminating the delayed phase CT to reduce radiation exposure in routine post-EVAR CT scanning will require more data, ideally from a large, multicenter study or meta-analysis.

## Conclusions

No aneurysmal sac expansion was found in patients with T2E visualized in the delayed phase in CTA 24 months after EVAR. However, the prevalence of aneurysmal sac expansion in T2E patients presenting on CTA phase was not statistically significantly higher than in patients on delayed phase. Age more than 80 years and initial aneurysmal sac diameter were significantly associated with aneurysmal sac expansion.

**Abbreviations**

AAA Abdominal aortic aneurysm
T2E Type II endoleak

CTA Computed tomography angiography
EVAR Endovascular aortic aneurysmal repair
IMA Inferior mesenteric artery

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**Author contributions**
SK: Conception, design of work, data analysis and manuscript writing. JW: Data collection, image interpretation. KP: image interpretation, data analysis and manuscript writing. All authors have approved the submitted version of the manuscript.

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**Availability of data and materials**
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Ethics approval and consent to participate**
This study was approved by the Institutional Review Board.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare that they have no competing interests.

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## Publisher's Note