Background and study aims: Bleeding after colonoscopic resection of pedunculated polyps cannot be easily predicted. The aims of this study were to evaluate the blood supply in pedunculated polyps and to clarify the optimal position on the polyp stalk for snare placement to prevent post-polypectomy hemorrhage.

Patients and methods: In one institution, 11 pedunculated polyps from 11 patients were studied prospectively. All polyps were resected at the base of the stalk using a snare wire with electrocautery. Histologic axial sections from the apex and base of the stalk were examined with hematoxylin eosin and elastica stains. Elastica stains were used to identify blood vessels. The cross-sectional area of the stalk, total vessel area, maximum diameter of artery/arteriole lumen, number of thick (≥0.1 mm) vessels, and number of arteries/arterioles were measured in each section with image processing software. Wilcoxon signed-ranks test was used for comparison.

Results: The median polyp diameter was 16 mm (range 7 to 24 mm) and median length of the stalk was 11 mm (range 7 to 23 mm). Two invasive cancers (T1) were included. The maximum diameter of the arterial/arteriolar lumen was greater at the base (P = 0.0044), whereas the ratio of the vessel area to the cross-section area was greater at the apex (P = 0.016). The number of thick vessels and arteries/arterioles were equivalent between apex and base.

Conclusions: Morphometric study of the blood supply of pedunculated polyps confirmed that the optimal site for the excision of pedunculated polyps is in the middle of the stalk.
Patients and methods

Participants
Before study commencement, the local committee on human experimentation approved this study. We conducted a prospective study in a single center. From April 2011 to November 2012, 11 patients with pedunculated polyps (median age 63 years, range: 37 to 87; all male) were enrolled non-consecutively at our academic endoscopy center. Patients whose pedunculated polyps were suspected to have malignant stalk invasion were excluded. Written informed consent to examine the resected specimens was obtained from all patients after colonoscopic resection.

Endoscopic polypectomy procedure
All patients received bowel preparation with 2 or 3L of polyethylene glycol electrolytic solution (Niflec: Ajinomoto, Tokyo, Japan). To minimize damage from electrocautery and allow precise evaluation of the histology of the stalk, polypectomy was carried out using thin snare wires (0.3mm diameter, SD-230U-25, Olympus, Tokyo) without submucosal injection. All polyps were resected using electrocautery with the ICC 200 electrosurgical generator (ERBE, Tubingen, Germany): Endocut, effect 3 (output limit 120W). All polyps were resected at the base of the stalk. An example endoscopic image is shown in Fig. 1. All resected specimens were pinned immediately after resection on a board (Fig. 2). Before formalin fixation, the maximum diameter of the polyp head, the maximum diameter of the stalk, and the length of the stalk were measured with calipers.

Histologic examination
All resected polyps were fixed and embedded in paraffin. Axial sections from the head and base of all stalks were obtained and stained with hematoxylin eosin and elastica (Fig. 3). Arteries and arterioles were defined as blood vessels possessing the internal elastic membrane of the intima, identified with elastica stains. To discriminate lymphatic channels from blood vessels, D2–40 stains were performed on the first three cases. However, very few lymphatic vessels were recognizable in sections. Therefore, in this study, all vessels are defined as blood vessels.

Image analyses
All histologic images were processed with a virtual pathology system (Nanozoomer digital pathology, Hamamatsu photonics, Japan). The cross-sectional area of the stalk, total vessel area, number of vessels measuring ≥0.1 mm, number of arteries/arterioles (possessing internal elastic membrane), and maximum diameter of arteries/arterioles lumen were measured with image processing software (Image J [13]). The cross-sectional area of the stalk was defined as the area excluding the epithelial layer (Fig. 4).
Statistics
The cross-sectional area of the stalk, total vessel area, number of vessels measuring ≥0.1 mm, number of arteries/arterioles and maximum diameter of arteries/arterioles lumen were compared between the apex and base of the stalk, using the Wilcoxon signed-ranks test. The ratio of total vessel area to cross-sectional area also was analyzed. The criterion for statistical significance was $P < 0.05$. All statistical analyses were performed with Stata 11.0 (Stata Corp., TX, USA).

Results
Characteristics of the polyps in the 11 patients studied are shown in Table 1. Eight polyps were located in the sigmoid colon and three in the ascending colon. The median size of the polyp head was 16 mm (range 7–24 mm) and median stalk length was 11 mm (range 7–23 mm). Two of the polyps were T1-stage cancers (submucosal invasion depth: 950 μm and 1000 μm), and were included in the analyses.

Table 1  Characteristics of 11 polyps

| Polyp | Location     | Maximum diameter of the head (mm) | Maximum diameter of the stalk (mm) | Length of the stalk (mm) | Histology                                      |
|-------|--------------|-----------------------------------|-----------------------------------|--------------------------|------------------------------------------------|
| 1     | Sigmoid      | 15                                | 12                                | 13                       | Cancer in situ, tub21                            |
| 2     | Sigmoid      | 12                                | 9                                 | 11                       | tubular adenoma, high-grade                      |
| 3     | Sigmoid      | 24                                | 12                                | 8                        | T12, tub13                                      |
| 4     | Sigmoid      | 20                                | 5                                 | 12                       | Tubular adenoma, high-grade                      |
| 5     | Sigmoid      | 16                                | 12                                | 8                        | T12, tub13                                      |
| 6     | Ascending    | 7                                 | 5                                 | 7                        | Tubular adenoma, low-grade                       |
| 7     | Ascending    | 10                                | 10                                | 12                       | Tubular adenoma, low-grade                       |
| 8     | Sigmoid      | 18                                | 7                                 | 11                       | Tubular adenoma, low-grade                       |
| 9     | Sigmoid      | 14                                | 7                                 | 8                        | Tubulovillous adenoma                            |
| 10    | Sigmoid      | 22                                | 13                                | 9                        | Traditional serrated adenoma                     |
| 11    | Ascending    | 16                                | 7                                 | 16                       | Cancer in situ, tub13                            |

1 moderately differentiated type tubular adenocarcinoma
2 tumor invading submucosal layer
3 well-differentiated type tubular adenocarcinoma

Table 2  Comparison between apex and base

|                     | Apex                          | Base                          | P-value |
|---------------------|------------------------------|-------------------------------|---------|
| Cross-section area (mm²) | Median 7.89, Range 0.74–23.0 | Median 10.31, Range 1.54–26.5 | 0.0099  |
| Vessel area (mm²)     | 1.58, Range 0.14–4.10        | 1.07, Range 0.19–3.78         | 0.72    |
| Ratio of CSA to vessel area | 0.18, Range 0.07–0.30 | 0.13, Range 0.07–0.24         | 0.016   |
| No. of vessels (≥0.1 mm) | 43, Range 12–72             | 43, Range 15–86               | 0.96    |
| No. of arteries/arterioles | 3, Range 1–3               | 3, Range 2–7                  | 0.37    |
| Maximum size of arteriole (mm) | 0.48, Range 0.08–1.53  | 0.74, Range 0.15–1.66         | 0.0044  |

Significant P-values are expressed in bold.
1 cross-section area.

Fig. 4  a Cross-sectional area of the stalk apex. b Cross-sectional area of the stalk base. Two different sections from the same polyp are shown. The maximum diameter of the arteries/arterioles lumen in the base is greater than that of the apex. In contrast, the ratio of the vessels to the cross section is greater in the apex than the base. However, the vessel area, number of vessels, and number of arteries/arterioles are equivalent between the apex and base.
Discussion

To our knowledge, the microscopic blood supply of the stalk of pedunculated colon polyps has been the focus of limited study. Because it is challenging to evaluate the quantity of blood supply in real time, we chose instead to investigate the histology of the vessels in the stalk. The density, diameter, and morphology of the vessels were used as surrogate markers for blood supply. We searched PubMed using the terms “pedunculated polyp” and “blood supply” and found only one report on this issue. Dobrowolski et al. studied perpendicular sections of the mucosal surface to assess microscopic blood supply [6]. That approach might not be sufficient for morphometric study of vessel number and diameter because the vessels run longitudinally in the stalk. In contrast, we used axial sections of the stalks, easily identifying the exact number of vessels, as well as the maximum diameter of the vessels on a pathology slide. Indeed, the number of vessels measuring ≥100 μm was much higher in our study using axial section, compared with Dobrowolski and colleagues’ study, which used longitudinal section (15–86 vs. 1–4 at the base of the stalk).

Our study has shown that the total vessel area, number of vessels measuring ≥100 μm, and number of arteries/arterioles did not differ between the apex and the base of the stalk. Our results suggest that the stalk position for snare resection of pedunculated colon polyps is not relevant for prevention of hemorrhage after resection. Nevertheless, oncologic aspects are important, because our 11 polyps included two invasive cancers. Although resection close to the polyp head is safer for avoiding perforation, a sufficient margin is required to achieve complete resection of invasive cancer. Therefore, resection close to the head is not optimal from an oncologic perspective.

It is our practice to primarily apply prophylactic clipping after resection of pedunculated polyps to fully close the resection site on the stump of the residual stalk. In our experience, with delayed bleeding after pedunculated polyp resection, bleeding occurs at the edge of the stump. Our series has shown that the stalk contains a far higher number of vessels than previously expected. Accordingly, complete closure by clipping may be ideal for eradication of delayed bleeding, even though it can be more difficult to achieve technically. Stalk vessel number may explain the lower reported efficacy of prophylactic clipping after polypectomy.[10, 14, 15]

There are acknowledged limitations to our study. Its small size limits the generalizability of the results. Despite that, we believe that the information presented here regarding the blood supply of pedunculated polyps is useful to colonicoscopists.

In conclusion, morphometric study of the blood supply of pedunculated polyps confirmed that the optimal site for excision of pedunculated polyps is in the middle of the stalk, as recommended by experts. [12] In addition, our findings that the stalk contains a greater number of vessels than previously expected may explain why delayed bleeding can occur even after prophylactic clipping.

Competing interests: None

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