（公財）榊原記念財団（2022 年度研究業績集）

# 血管外科診療におけるクラウド型モバイル端末ネットワークの有用性評価


**背　景**

破裂性腹部大動脈瘤（ruptured abdominal aortic aneurysm ; rAAA）の診療では，診断から緊急手術開始までに要する時間が患者の生存に影響する．我々は 2011 年から rAAA に対しステントグラフト内挿術（endovascular aneurysm repair;EVAR）を第一選択とする戦略を採用している．また rAAA 診療に関わる院内各部署の携帯端末上でコミュニケーションアプリを用いたクラウドネットワークを形成し，患者情報を共有し治療に要する時間短縮を図る試みを行っている．今回 rAAA 診療における，アプリによるクラウドネットワーク導入の影響を単施設，historical control 研究として調査したために報告する．

**方　法**

2011 年より我々は rAAA 診療を開始し，2018 年 1 月よりコミュニケーションアプリである Join®（Allm 社）を用いて院内各部署の携帯端末上に rAAA ネットワークを導入した．アプリ導入の前後に緊急 EVAR を行った rAAA 症例をそれぞれ historical control 群（導入前），アプリ群（導入後）とし，2 群の成績を単施設・後方視的研究として比較検証した．主要評価項目は rAAA 症例の病院到着 -EVAR 開始までに要した時間，および CT 診断 -EVAR 開始までに要した時間とし，副次評価項目は周術期死亡率，主要合併症発生率，術後在院日数，とした．

**結　果**

Historical control 群は 11 例，アプリ群は 6 例であった．Control 群とアプリ群の来院 -EVAR 時間はそれぞれ 138.1 ± 46.0 分 vs 94.3 ± 22.0 分（P=.025 <0.05），CT–EVAR 時間は 93.4 ± 36.0 分 vs 61.2 ± 23 分（P=.043 <0.05）であった．来院 -CT 撮像までの時間（p=0.61），周術期死亡率（p=0.55），周術期主要合併症発生率（p=0.65），術後在院日数（p=0.87）においては，両群間に統計学的な有意差を認めなかった．

**結　語**

アプリによる院内 rAAA ネットワーク導入により，rAAA 症例の来院 -EVAR 開始時間，CT 診断 -EVAR 開始時間の短縮を達成し得た．今後，携帯端末上の rAAA ネットワークが rAAA 治療の成績を改善し得るかどうか，更なる調査研究が望まれる．



福島宗一郎[※，※※]，大木　隆生[※]，戸谷　直樹[※，※※]，奥野　憲司[※※※]
鹿瀬　陽一[※※※※]，秋葉　直志[※※]

※東京慈恵会医科大学　外科学講座
　血管外科分野
※※東京慈恵会医科大学附属柏病院
　血管外科
※※※東京慈恵会医科大学附属柏病院　救急部
※※※※東京慈恵会医科大学附属柏病院　麻酔科

血管外科診療におけるクラウド型モバイル端末ネットワークの有用性評価

# A MOBILE COMMUNICATION APPLICATION FOR THE MANAGEMENT OF RUPTURED ABDOMINAL AORTIC ANEURYSM: 1YEAR RESULTS OF A SINGLE-CENTER HISTORICAL CONTROL STUDY

Soichiro Fukushima[※,※※], Takao Ohki[※], Naoki Toya[※,※※], Kenji Okuno[※※※],
Yoichi Kase[※※※※], Tadashi Akiba[※※※※※]

※Division of Vascular Surgery, Department of Surgery, The Jikei University School of Medicine
※※Department of Surgery, Division of Vascular Surgery, The Jikei University Kashiwa Hospital
※※※Department of Emergency Medicine, The Jikei University Kashiwa Hospital
※※※※Department of Anesthesiology, The Jikei University Kashiwa Hospital
※※※※※Department of Surgery, The Jikei University Kashiwa Hospital

**Article Type**: Original Article
**Key Words**: Ruptured abdominal aortic aneurysm, Mobile communication apps, JOIN, EVAR
**Author contributions**:
SF, NT, KO, YK, and TA were involved in the patients' management.
SF drafted the manuscript and performed the acquisition of data.
NT, TO revised the manuscript.
All authors approved the final manuscript.

**Conflict of interests**
Dr. Takao Ohki is a paid consultant for W.L. Gore & Associates.
The other authors declare that they have no conflict of interest in this study.

**Abstract**

**Objective**:

In the treatment of ruptured abdominal aortic aneurysm (rAAA), the time from diagnosis to treatment influences patient's survival. We established a mobile communication application (MCA) cloud network to share patient information and reduce time for starting rAAA treatment. We report the 1-year results of a single-center historical control study.

**Methods**:

Among 40 rAAA patients who attended between June 2011 and March 2019, 17 who underwent emergency endovascular aneurysm repair (EVAR) were included. We established a Join (Allm Inc., Tokyo, Japan) MCA network between vascular surgeons, anesthesiologists, and emergency and operating room staff. Primary endpoints were the time from arrival (arrival–operation time) or computed tomography (CT) scan (CT–operation time) to EVAR. Secondary endpoints included perioperative mortality, major adverse events, and postoperative hospital stay.

**Results**:

The number of rAAA cases before (standard [S] group) and after (MCA group) introduction of the MCA network was 11 and 6, respectively. In the S and MCA groups, arrival–operation time was 138.1 ± 46.0 min and 94.3 ± 22.0 min, respectively (P=.025) and CT–operation time was 93.4 ± 36.0 min and 61.2 ± 23 min, respectively (P=.043). There were no significant between-group differences in time from arrival to CT scan (P=.61), perioperative deaths (P=.55), major adverse events (P=.65), or postoperative hospital stay (P=.87).

**Conclusions**:

Following introduction of an MCA network, the time from patient arrival or CT scan to EVAR was reduced in rAAA management. Further investigations should be considered whether MCAs can contribute to improvements in rAAA patient survival.

**Introduction**

The treatment of ruptured abdominal aortic aneurysms (rAAAs) using endovascular aneurysm repair (EVAR) combined with occlusion balloons for aortic cross-clamping was reported in 1999 by Ohki et al.[1,2]; thereafter, EVAR first strategy for rAAAs expanded widely.

The clinical outcomes of EVAR for rAAAs has been reported by several randomized control trials with short- and medium-term results. Although a statistically significant benefit of rAAA treatment using EVAR on long-term mortality compared with open surgical repair has not been clearly demonstrated, the following outcomes have been reported: improved postoperative mortality within 3 or 8 years, reduced operating time, reduced hemorrhage, reduced postoperative length of stay among survivors of rAAA, and reduced healthcare costs[3~6]. In addition, aortic occlusion balloons, which can be inserted with 7 Fr small-diameter sheaths, and endovascular aneurysm sealing, which can be quickly deployed with good operability, have also been used in recent years to treat rAAAs[5]; many rAAA patients have benefited from these new treatment devices.

However, the length of time from diagnosis to treatment of rAAA, during which the operative procedure is determined and optimized, influences the prognosis of the patient, including mortality. Various time-consuming factors, in addition to responding to patients, are experienced by vascular surgeons prior to an emergency operation, including diagnostic and post-diagnostic examinations, pathology briefings, acquisition of patient consent for surgery and transfusion, contact and coordination with the operating room, and selection of EVAR devices based on computed tomography (CT) images.

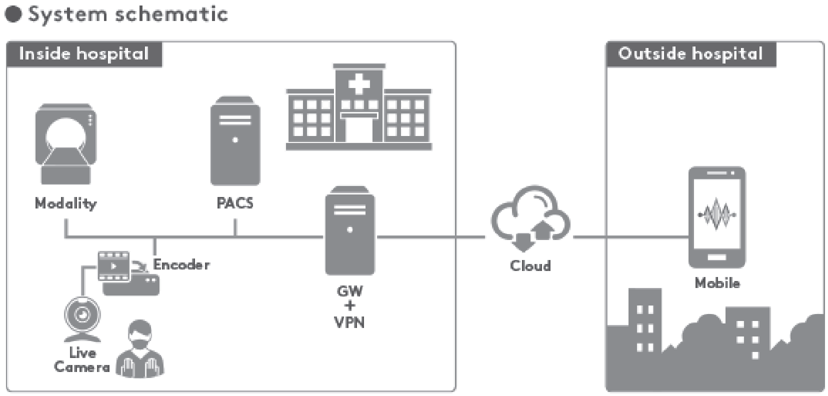
In hospitals where a qualified vascular surgeon is not routinely stationed, an emergency physician who has diagnosed an rAAA may contact a specialist offsite to attend the hospital and perform emergency surgery. In such cases, sharing of accurate patient information, including their diagnosis and condition, between vascular surgeons, emergency physicians, anesthesiologists, and surgical departments, is important during the prompt preparation of emergency surgery.

We have been treating patients with rAAAs using EVAR as an initial strategy since June 2011. In an attempt to minimize the time from patient arrival to the emergency operation, in-hospital networks using the Join (Allm Inc., Tokyo, Japan) mobile communication application (MCA) were formed in January 2018, which have been used to share rAAA patient information, including CT data and preparations for surgery. The Join MCA meets a security standard in Japan and is approved as medical instrument (medical equipment approval number: 227AOBZX00007000). The protocol for this study was reviewed and approved by the Institutional Ethical Review Board (IRB) of our hospital, (IRB no. 29-293[8909]). We report 1 year results of a single-center historical control study investigating a usefulness of an MCA for the management of rAAAs.

**Methods**

Between June 2011 and March 2019, we treated 40 rAAA cases using a surgical approach. Among these patients, we excluded 10 with Fitzgerald classification I, who had stable hemodynamics and underwent urgent treatment on the day of arrival; 5 with Fitzgerald classification IV, who had unstable conditions making it difficult to verify the intervention effects; 1 who received open surgery for anatomical reasons; 2 with ruptured solitary iliac aneurysms; and 5 with in-hospital rAAA onset cases who did not require MCA. We included 17 rAAA patients with Fitzgerald classification II or III , who were treated by emergency EVAR.

Since January 2018, we established an in-hospital Join MCA network between the medical personnel who participated in rAAA management, including vascular surgeons, anesthesiologists, and emergency and operating room staff. Information about the condition of rAAA patients was shared, including CT scan data (pictures and videos), laboratory data, preparations for emergency EVAR, and blood transfusions, as required. The method of the Join MCA use was as follows: 1) the vascular surgeon




GW, gateway; VPN, virtual private network.

Fig. 1a
Hospital network using a Join® mobile communication application for the management of ruptured aortic aneurysms.

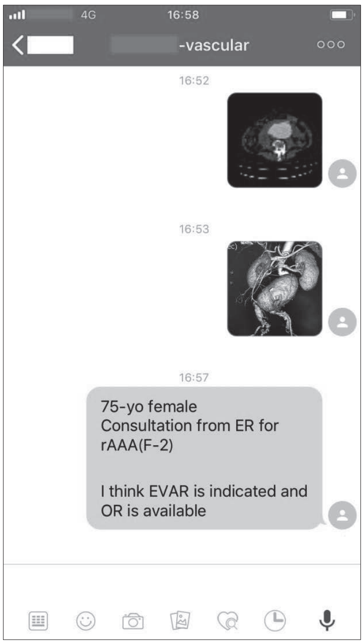



Fig. 1b
Picture of the Join® mobile communication application illustrating communication using a chat format for a ruptured abdominal aortic aneurysm patient.

or emergency physician who diagnosed an rAAA delivered patient information, including CT images, to MCA networks using cloud mobile terminals; 2) the network participants obtained information on cloud mobile terminals; and 3) each network participant began preparations for emergency EVAR simultaneously as quickly as possible, and maintained contact using a chat format (Fig. 1a and 1b) [7]. The Join MCA imposed no data limit and enabled scaling of images and measurement of aneurysm size and vessel diameters to determine the appropriate treatment strategy and device selection (Fig. 2).

rAAA cases treated before introduction of the MCA were defined as the Standard (S) group, whereas rAAA cases treated after introduction of the MCA were defined as the MCA group. We investigated the usefulness of the MCA for rAAA management by comparing the historical data.

Emergent surgery was performed by first inserting the occlusion balloon for the aortic cross-clamp through the common femoral artery (CFA) under local anesthesia and then inserting the main body of the stent graft from the opposite side of the CFA. Following the aortic cross-clamp, a rapid conversion to general sedation was conducted by the anesthesiologist.

Our hospital stocked the Excluder stent graft (W.L. Gore & Associates, Flagstaff, Arizona, USA), which has zero porosity, for emergency use only, and selected the appropriate device on the basis of the patient anatomy. The proximal sealing length was >15 mm in every case. For cases in which a sufficient sealing length could not be secured below the renal artery due

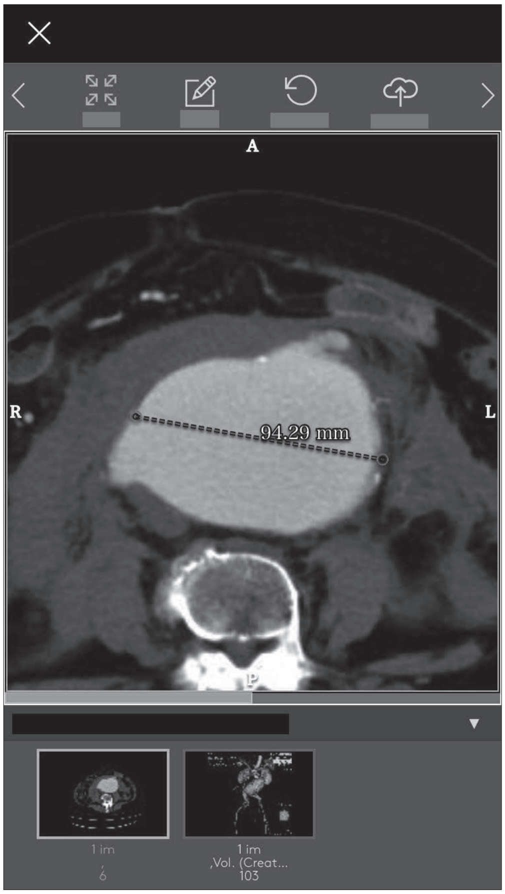



Fig. 2
Computed tomography measurement of aneurysmal size using the Join ® mobile communication app.

to a short or angulated proximal neck, intentional renal artery coverage was conducted to secure the proximal sealing and prevent mortality.

Treatment for ruptured aorto-iliac aneurysms was conducted using a stent graft extension for the external iliac artery with internal iliac artery coil embolization on the aneurysmal side. The technical success was defined by the Society for Vascular Surgery guidelines[9]. If there was no typeIor III endoleak and the planned procedure was completed, we judged the procedure a technical success. The primary endpoints were the time from arrival to start of emergency EVAR (arrival–operation time) and the time from CT scan to the start of emergency EVAR (CT–operation time). Secondary endpoints were perioperative mortality, incidence of major adverse events, and postoperative hospital stay.

**Statistical analysis**

Data are presented as means ± standard deviations. The results were analyzed using GraphPad Prism® version 7.0 (GraphPad, San Diego, CA, USA). Differences between the groups were tested using the Chi-square test for categorical variables and the t-test or Mann–Whitney U-test for continuous variables. A P value < 0.05 indicated statistical significance.

**Institutional Review Board permission**

We obtained permission to conduct this study from our hospital's Institutional Review Board. (IRB number : 29-293(8909))

**Results**

The number of cases in the S and MCA groups was 11 and 6, respectively. The mean age of patients in the S and MCA groups was 75.5 ± 7.0 years and 80.0 ± 7.0 years, respectively; the ratio of male patients was moderately higher in the S group (eight cases [72.7%] versus three cases [50.0%] in the MCA group).

The mean size of the maximum shorter aneurysm diameter was 68.7 ± 12.0 mm and 71.8 ± 13.0 mm in the S and MCA groups, respectively. The numbers of cases with Fitzgerald classification II or III were 2 (18.2%) and 9 (81.8%), respectively, in the S group, and 2 (33.3%) and 4 (66.7%), respectively, in the MCA group; there were no statistically significant differences in rAAA classification between groups. Patient characteristics are reported in Table 1.

In the S and MCA groups, arrival–operation time was 138.1 ± 46.0 min and 94.3 ± 22.0 min, respectively (P=.025) and CT–operation time was 93.4 ± 36.0 min and 61.2 ± 23.0 min, respectively (P=.043); both outcomes were significantly shorter in the MCA group. The time from arrival to CT scan in the S and MCA groups was 37.6 ± 19.0 min and 33.2 ± 13.0 min, respectively (P=.61); there were no statistically significant differences between the groups.

Table 1. Baseline data of the patients.

| Characteristic | S group (*n* = 11) | MCA group (*n* = 6) | P-value |
|---|---|---|---|
| Age (years), mean ± SD | 75.5 ± 7.4 | 80.0 ± 7.1 | .29, ns |
| Male sex, *n* (%) | 8 (72.7) | 3 (50.0) | .38, ns |
| Aneurysm diameter (mm), mean ± SD | 68.7 ±12.4 | 71.8 ±13.0 | .66, ns |
| Fitzgerald classification, n (%) | | | |
| II | 2 (18.2) | 2 (33.3) | .55, ns |
| III | 9 (81.8) | 4 (66.7) | .55, ns |
| Preoperative cardio pulmonary arrest, n (%) | 0 (%) | 0 (%) | >.99, ns |
| Preoperative hypovolemic shock, n (%) | 9 (81.8) | 4 (66.7) | .55, ns |

S, standard; SD, standard deviation; MCA, mobile communication application.

In the S and MCA groups, emergency EVAR was conducted during the weekend or holidays (that is, Saturday, Sunday, and holidays) for five cases (45.5%) and two cases (33.3%) respectively, and during a non-duty time based on general working hours in Japan (17:00–7:00) for seven cases (63.6%) and eight cases (66.7%), respectively; there were no statistically significant differences in these outcomes between the two groups.

In the S and MCA groups, the operating time was 140.1 ± 32.7 min and 140.5 ± 21.3 min, respectively, and blood loss during the operation was 272.0 ± 271.3 mL and 151.7 ± 93.2 mL, respectively.

Insufficient circulation maintenance resulting from hypovolemic shock occurred in one patient (9.1%) in the S group and one patient (16.7%) in the MCA group prior to aortic cross-clamping with an occlusion balloon and required cardiopulmonary resuscitation.

Insertion of the 12 Fr. sheath for stent graft insertion was difficult in one patient in the S group, who had severe stenosis and calcification of the external iliac artery; therefore, the patient was treated by EVAR using an aorto-uni-iliac and extra-anatomical femoro–femoro bypass using an expanded polytetrafluoroethylene graft (Propaten®; W.L. Gore & Associates) and coil embolization of the stenotic side of the common iliac artery. We treated one patient in each of the group, both who had a severe angulated short proximal neck, using EVAR with intentional renal artery coverage to ensure the proximal sealing; the patient in the S group was diagnosed with a 75% stenosis of the proximal superior mesenteric artery and required placement of an additional bare metal stent using a self-expandable stent for the bail out of the stenosis via the right brachial artery. The mean stent graft device number used in the S and MCA groups was 4.0 ± 0.9 and 4.6 ± 1.7, respectively. The results of these perioperative treatments are presented in Table 2.

There were two deaths within 30 days after surgery in each of the S (18.2%) and MCA (33.3%) groups, respectively (P=.55). Among the S group, two patients (18.2%) developed abdominal compartment, which

Table 2. Procedural and operative findings in the S group and MCA groups.

| | S group | MCA group | |
|---|---|---|---|
| Finding | (*n* = 11) | (*n* = 6) | P-value |
| Arrival to operation time (min), mean ± SD* | 138.1±46.4 | 94.3±21.6 | .025 |
| CT scan to operation time (min), mean ± SD† | 93.4±36.4 | 61.2±22.5 | .043 |
| Arrival to CT scan time (min), mean ± SD‡ | 37.6±19.4 | 33.2±13.3 | .61, ns |
| Number of holidays, days (%)§ | 5 (45.5) | 2 (33.3) | .65, ns |
| Number of non-duty time, n (%)\|\| | 8 (72.7) | 4 (66.7) | .81, ns |
| | | | |
| Operation finding | S group | MCA group | |
| | (*n* = 11) | (*n* = 6) | P-value |
| Technical success rate, *n* (%) | 11/11 (100.0) | 6/6 (100.0) | >.99, ns |
| Operation time (min), mean ± SD | 140.1 ± 32.7 | 140.5 ± 21.3 | .97, ns |
| Blood loss (ml), mean ± SD | 272.0 ± 271.3 | 151.7 ± 93.2 | .14, ns |
| Mean device number (*n*), mean ± SD | 4.0±0.9 | 4.6±1.7 | .40, ns |
| Additional procedure | | | |
| Coil embolization of iliac artery, n (%) | 1 (9.1) | 1 (16.7) | .70, ns |
| Intentional renal artery coverage, n (%) | 2 (18.2) | 1 (16.7) | >.99, ns |
| SMA stenting, n (%) | 1 (9.1) | 0 (0) | .48, ns |
| Aorto-uni-iliac with F-F bypass, n (%) | 1 (9.1) | 0 (0) | .48, ns |

*The required time (minutes) from hospital arrival to the emergency operation; †the required time (minutes) from the computed tomography (CT) scan to the emergency operation; ‡the required time (minutes) from hospital arrival to the CT scan; §the number of emergency operations conducted on Saturday, Sunday, and holidays; ||the number of emergency operations conducted between 17:00 and 9:00.

F-F, femoral-femoral; MCA, mobile communication application; S, standard; SD, standard deviation; SMA, superior mesenteric artery.

was diagnosed as an intravesical pressure >40 mmHg. In addition, one patient (9.1%) developed a massive pulmonary embolism caused by a residual intrapelvic massive hematoma 11 days after emergency EVAR; the patient experienced cardiopulmonary arrest that was recovered by resuscitation and was subsequently diagnosed with hypoxic encephalopathy and transferred to another hospital at postoperative day 93. In the MCA group, one patient presented non-obstructive mesenteric ischemia 58 days after emergency EVAR, which required an additional laparotomy. The number of major adverse events in the S and MCA groups was 6 (54.5%) and 4 (66.7%), respectively (P=.65); there was no statistically significant difference between the groups. The mean postoperative hospital stay was 51.1 ± 31.5 days among the eight surviving patients in the S group and 47.7 ± 24.7 days among the three surviving patients in the MCA group (P=.87); there was no statistically significant difference between the groups. Postoperative results of both groups are reported in Table 3.

**Discussion**

**MCA shortens rAAA patient arrival-operation time**

In the treatment of rAAA, the time from diagnosis to emergency treatment greatly influences survival. A retrospective study conducted by Vetrhus et al.[10], which investigated 47 untreated rAAA cases after in-hospital diagnosis, reported a mean time from patient arrival to death of 7.4 h. Another study conducted by Van Beek et al.[11], which investigated the natural histories of 47 untreated rAAA patients after hospital arrival, reported a mean time from hospital arrival to death caused by aneurysm rupture of 2.2 h. In the treatment of rAAA, there are a few hours of lag time from hospital arrival to the irreversible collapse of vital conditions, with the exception of patients who presented with cardiopulmonary arrest on arrival. We have to treat rAAA patients within this “golden” time period without a delay in the start of emergency surgery, regardless of the presentation with temporally stable conditions.

In the management of rAAA, clinicians must treat the critical patient while providing an explanation

Table 3. Operative findings in the S group and MCA groups.

| Finding | Total (*n* = 17) | S group (*n* = 11) | MCA group (*n* = 6) | P-value |
|---|---|---|---|---|
| 30-Day mortality, *n* (%) | 4 (23.5) | 2 (18.2) | 2 (33.3) | .55, ns |
| Major adverse event, *n* (%) | 10 (58.8) | 6 (54.5) | 4 (66.7) | .65, ns |
| Abdominal compartment, n (%) | 3 (17.6) | 2 (18.2) | 1 (16.6) | >.99, ns |
| Sepsis, n (%) | 2 (11.8) | 1 (9.1) | 1 (16.7) | .70, ns |
| Non-obstructive mesenteric ischemia, n (%) | 1 (5.9) | 0 (0) | 1 (16.7) | .35, ns |
| Renal replacement therapy, n (%) | 3 (17.6) | 2 (18.2) | 1 (16.7) | >.99, ns |
| Pulmonary embolism, n (%) | 1 (5.9) | 1 (9.1) | 0 (0) | .48, ns |
| Postoperative hospital stay (days), mean ± SD | 50.1±29.6 | 51.1±31.5 | 47.7±24.7 | .87, ns |

MCA, mobile communication application.

of the condition and required treatment to the patient and their family members, contacting the operating room staff in preparation for emergency surgery, preparing blood transfusion as needed, and deciding the optimal strategy and appropriate device. The Join MCA network enables simultaneous communication among participants in each department, using a chat format on a mobile terminal, of rAAA patient information including CT data, conditions, preparation status of the operation room, such as requirements for anesthesia and blood transfusion, and the preparation status of the required EVAR device.

In this study, the time from arrival of the patient to emergent surgery was significantly reduced after introduction of the MCA network in our hospital, which was attributed to a reduced time between the CT scan and emergent surgery, regardless of the time between arrival and the CT scan. Sharing real-time information in an MCA network using a mobile terminal promoted the speed of communication, which contributed to the reduced time from CT scan to the start of emergency treatment. We believe that the reduced time period observed after introduction of the MCA network was achieved by the prompt and simultaneous communication in each department of our hospital.

However, there were no statistically significant positive effects on perioperative mortality, major adverse events, and postoperative hospital stay after introduction of the MCA network; this may be explained by the small sample size of this study and the difficulty of identifying a comparable rAAA patient group. In this study, we included only rAAA patients who had been diagnosed as Fitzgerald classification II or III and excluded those diagnosed as Fitzgerald classification I or IV, or with ruptured solitary iliac aneurysms. However, we did not find a positive effect on preoperative mortality and major adverse events after introduction of the MCA. Further studies are needed, which investigate the efficacy of MCA networks for the management of rAAA using a larger sample of rAAA patient and a prospective multicenter design.

**Reducing the burden on medical staff by MCA**

Physicians working with acute disease sometimes experience consultation for emergency cases during the night, holidays, or out-of-hospital hours. In such cases, non-specialists who are responsible for patients would want a prompt consultation by specialists or attending physicians who can provide accurate diagnoses and treatment decisions. Telephone consultation has been the primary conventional method; however, the introduction of MCA enables network participants to share patient information both inside and outside of the hospital, including pictures or movies, such as those from CT.

During this study, we performed vascular surgery, including rAAA treatment, in a system of three vascular surgeons who were available 24 h a day, 365 days a year. However, for a variety of circumstances, a vascular surgeon may not always be available in the hospital to attend to emergency patients, including overnight and on holidays. In these settings, communication between non-specialists and specialists, which leads to more accurate diagnoses and prompt decisions, is expected to reduce the burden on specialized doctors, including vascular surgeons, who have traditionally been required to attend the hospital for diagnosis. MCA networks provide accurate diagnosis and treatment decisions by a in-hospital physician who was responsible for emergency patients, regardless of their specialty.

MCA networks are widely applied as communication tools between patients and their surgeons[12)], in settings such as stroke response[13)] and intensive care units[14)] and in the treatment of acute-phase diseases, such as rAAA reported in this study. In a study that investigated the influence of MCA communication between postoperative patients and their surgeons, patients reported easier communication with their surgeons, the ability to minimize the need for hospital follow-up visits, and increased knowledge regarding management of their illness[12)]. In addition to these patient benefits, MCA networks are expected to decrease the burden on specialized physicians of the attending hospital to confirm diagnosis and treatment decisions. These strengths of MCA networks are thought to be more significant in the present age, when working reforms of doctors is of concern.

**Conclusions**

By sharing rAAA patient information between medical personnel using an MCA, and simultaneously carrying out preparation of the emergency operation in each hospital department, we achieved to reduce the time from patient arrival to the emergency operation. In-hospital network formation using an MCA is useful in rAAA practice, and further studies with much larger patient samples that investigate whether this approach can improve postoperative survival in patients with rAAA should be considered.

**Acknowledgment**

This work was supported by Sakakibara Heart Foundation Cardiovascular Research Program.

**Abbreviations**

| | |
|---|---|
| CFA | Common femoral artery |
| CT | Computed tomography |
| EVAR | Endovascular aneurysm repair |
| MCA | Mobile communication application |
| RAA aneurysm | Ruptured abdominal aortic |
| SMA | Superior mesenteric artery |
| TM | The manuscript |
| VPN | Virtual private network |

**References**

1) Ohki T, Veith FJ, Sanchez LA, Cynamon J, Lipsitz EC, Wain RA, et al. Endovascular graft repair of ruptured aortoiliac aneurysms. J Am Coll Surg 1999;189:102-12

2) Ohki T1, Veith FJ. Endovascular grafts and other image-guided catheter-based adjuncts to improve the treatment of ruptured aortoiliac aneurysms. Ann Surg 2000;232:466-79.

3) Patel R, Sweeting MJ, Powell JT, Greenhalgh RM, EVAR trial investigators. Endovascular versus open repair of abdominal aortic aneurysm in 15-years' follow-up of the UK endovascular aneurysm repair trial 1 (EVAR trial 1): a randomised controlled trial. Lancet 2016;12;388:2366-74.

4) Reimerink JJ, Hoornweg LL, Vahl AC, Wisselink W, van den Broek TA, Legemate DA, et al. Endovascular repair versus open repair of ruptured abdominal aortic aneurysms: a multicenter randomized controlled trial. Ann Surg 2013; 258:248-56.

5) IMPROVE Trial Investigators. Endovascular or open repair strategy for ruptured abdominal aortic aneurysm: 30-day outcomes from IMPROVE randomised trial. BMJ 2014;348:f7661.

6) IMPROVE Trial Investigators. Comparative clinical effectiveness and cost effectiveness of endovascular strategy v open repair for ruptured abdominal aortic aneurysm: three-year results of the IMPROVE randomised trial. BMJ. 2017 14;359: j4859.

7) De Bruin JL, Brownrigg JR, Karthikesalingam A, Patterson BO, Holt PJ, Hinchliffe RJ, et al. Endovascular aneurysm sealing for the treatment of ruptured abdominal aortic aneurysms. J Endovasc Ther 2015;22:283-7.

8) Https://www.allm.net/en/join-en/

9) Chaikof EL, Dalman RL, Eskandari MK, Jackson BM, Lee WA, Mansour MA, et al. The Society for Vascular Surgery practice guidelines on the care of patients with an abdominal aortic aneurysm. J Vasc Surg 2018, 67:2-77.

10) Vetrhus M, Reite A, Vennesland JB, Søreide K. Characteristics, stratification and time to death in a population-based cohort of patients with ruptured abdominal aortic aneurysms not undergoing surgery. World J Surg. 2018;42:2269-76.

11) van Beek SC, Vahl AC, Wisselink W, Balm R, Amsterdam Acute Aneurysm Trial Collaborators. Fate of patients unwilling or unsuitable to undergo surgical intervention for a ruptured abdominal aortic aneurysm. Eur J Vasc Endovasc Surg 2015;49:163-5.

12) Abelson JS, Kaufman E, Symer M, Peters A, Charlson M, Yeo H, et al. Barriers and benefits to using mobile health technology after operation: a qualitative study. Surgery 2017;162:605-11.
13) Munich SA, Tan LA, Nogueira DM, Keigher KM, Chen M, Crowley RW, et al. Mobile real-time tracking of acute stroke patients and instant, secure inter-team communication-the Join app. Neurointervention 2017;12:69-76.
14) Litton E, Elliott R, Thompson K, Watts N, Seppelt I, Webb SA. Using clinically accessible tools to measure sound levels and sleep disruption in the ICU: a prospective multicenter observational study. Crit Care Med 2017;45:966-71.