Seventh Conference of Directors of Information Technology, TICAL 2017 Management of ICTs for Research and Collaboration, San José, 3 to 5 July 2017

Remote Medical Education in Latin America

Kuriko Kudo[1], PhD, Shunta Tomimatsu[1], MS, Tomohiko Moriyama[1], MD, PhD, Miguel A. Tanimoto[2], MD, Salma Leticia Jalife Villalón[3], MS, Shuji Shimizu[1], MD, PhD

[1] Telemedicine Development Center of Asia, International Medical Department, Kyushu University Hospital, Fukuoka, Japan
kuricom@tem.med.kyushu-u.ac.jp

[2] National Institute of Medical Sciences and Nutrition Salvador Zubiran, Tlapan, Mexico
matanimoto@prodigy.net.mx

[3] Corporación Universitaria para el Desarrollo de Internet, A.C. (CUDI), Mexico City, Mexico
salmajalife@cudi.edu.mx

Abstract. Medicine is one of the most important subjects for remote education over Internet. However, there are not so many telemedicine programs running as expected, one of the reasons being the high demand for technologies for transmitting medical images clearly and smoothly. Our remote education project has realized high-quality transmission with low cost, and has been accepted in many hospitals in Asia and beyond. The aim of this manuscript is to summarize our current collaborative situations for further development. We analyzed our programs with Latin America, which were carried out from 2009 to 2016. Research and education network (REN) or commercial network, installed in each institution, was used. Digital video transport system (DVTS), H.323 and Vidyo were used as teleconference systems. Questionnaires were taken randomly to evaluate image resolution, image movement, sound quality, and programs. The total number of connected institutions increased to 48 institutions in seven countries in 2016. The annual number of programs increased to 17 in 2016, and endoscopy accounted for 65% (30/46) of all programs. DVTS (50%, 2/4) and H.323 (50%, 2/4) were used in first 4 years, however the main system changed to Vidyo (74%, 31/42) in the last 4 years. Image resolution, image movement and sound quality were “very good” or “good” in more than 92% of respondents. For programs, 98% commented that they were “very good” or “good”. The numbers of participating medical institutions and of organized programs dramatically increased with satisfactory image and sound quality and attractive programs for remote medical education. These rapid expansions were attributed to the big changes and advancement in Information and Communication Technology (ICT). It is quite useful to take full advantage of ICT in remote medical education, although it is more technically demanding than other educational fields, so that this would eventually provide advanced medical care to patients.

Keywords: telemedicine, remote medical education, research and education network, Latin America

Main theme: ICT Solutions for Teaching

1 Introduction

Medicine is one of the most important subjects among various teaching programs over Information and Communication Technology (ICT). Both medical science and clinical medicine have been continuously advancing in many specialties, and therefore there are tremendous amount of needs for learning new knowledge and advanced skills [1,2]. However, there are not so many programs running as expected, one of the reasons being the high demand for technologies that are required for telemedicine [3,4]. In medical education, much higher image quality than other fields of educational contents is essential, for example, to understand minute and complex anatomy such as very small blood vessels or thin membrane structures of human body or to make an accurate diagnosis from the subtle changes of gastric mucosa differentiating cancers from benign lesions by endoscopy. In addition, movies are quite often used for medical education such as for surgery, where 30 frames of high-quality still pictures must be transmitted per second without stagnation.

Emergence of research and education network (REN) and digital video transport system (DVTS) enabled us to establish the satisfactory remote education system in 2003, and the very first live demonstration of surgery was performed between Japan and Korea with the bandwidth of 30Mbps over Korea-Japan RENs [5]. In addition to the transmitted quality of live surgery, the cost benefit of DVTS, which is free software and requires only commercially available equipment like personal computers (PCs) and handy video cameras eliminating the need of costly special videoconferencing systems, which initiated the prevalence of practicality of telemedicine. The programs expanded to various subspecialties and to many other countries in Asia and beyond [6,7].

We started the collaborations with Latin America in 2009. In this report, we summarized our activities during the past 8 years, to introduce current situations and to discuss what to be done next.

2 Materials and Methods

In the present study we analyzed our remote education programs with Latin America, which were carried out during the period from 2009 to 2016. The programs were divided into two types, teleconference and live demonstration. Teleconference is a case conference using presentation materials such as medical videos. Live demonstration is the simultaneous delivery of medical technology; the audience can have a direct question to the moderator who is next to the operator. In a live demonstration, the personal information of the patient is not included. Moreover, the network security is enhanced by using the Advanced Encryption Standard (AES) encryption systems in accordance with the provisions of the hospital where demonstration was performed.

Regarding the requirements for remote connection, such as network, equipment and engineers, the existing ones of the participating institutions were used as much as possible. Existing network of the participating institutions were divided into two large groups: REN and commercial network. REN is a network for the purpose of academic

research, in which a number of research institutions around the world have been connected. High-speed network from 40Mbps to 4Gbps is provided, and it is also possible to control routing or bandwidth [8]. Commercial network is the normal network that can be purchased in agreement with the company; it provides a speed of 1 Mbps to 1 Gbps. However, the users bandwidth of the commercial network is not guaranteed because very large number of users access to the network. Moreover, the routing of commercial network is not controlled. It sometimes causes problems by asymmetrical routing for outgoing/incoming, and network congestion, especially in case of international connection.

DVTS, H.323 and Vidyo were used as teleconference systems, depending on the purposes and equipment status of the participating institutions [9,10]. DVTS is an Internet Protocol (IP) based on real-time audio visual communication tool developed by Keio University [11]. DVTS transmits images of 30 fps in standard definition (SD) without inter-frame compression. H.323 is the one of the standard systems sold by a number of companies, and is the most common system in the medical field [12]. H.323 needs a Global/Public IP address, and a network with a bandwidth of 1 to 8 Mbps for high definition (HD) transmission. Vidyo is a system sold by Vidyo™ (Hackensack, NJ) which works with original compression program called H.264/Scalable Video Coding (SVC). Vidyo is a software-based system which is able to be used with normal Internet, including 3G and Wifi. Vidyo allows connection from PCs, iPads and mobile, etc. There are hardware/software systems called VidyoRoom and VidyoDesktop for clients. VidyoDesktop is a software system, which acts well for normal conversation with a network of 1 Mbps to 2 Mbps; interactive transmission of camera image and microphone audio. In contrast to the fact that it works well with receiving presentation materials like surgical movies, transmission of moving images is quite limited. VidyoRoom is a hardware system, which enables transmission of high quality images, including surgical videos and live demonstration with full high definition (1080p/30fps) with 2 Mbps to 8 Mbps. We used the servers for Vidyo in Kyushu University Hospital, Japan.

In addition to the two-way communication systems, we streamed out video and audio of the programs. We used VidyoReplay system to stream out and to receive the streaming, a PC with Flash Player software connected to the Internet with 1 Mbps is required, accessing to the URL provided by the organizers.

We took structured questionnaires randomly after 2013, in order to obtain evaluations of the image and sound quality. For the participants in remote locations, we created questionnaires online or in digital data format, and asked participants by e-mail in advance. We collected answers after the programs ended. Audiences were required to evaluate image resolution, image movement, sound quality, and programs. The answers were classified into four levels: “very good,” “good,” “poor,” and “very poor.”

3 Results

3.1 Expanding institutions. Kyushu University Hospital, Japan, started teleconferences with Latin America in 2009 with University of Sao Paulo Ribeirao

Preto Hospital, Brazil, in July, and with Universidad Nacional Autonoma de Mexico, Mexico, in October, followed by Red Universitaria Nacional (REUNA) Santiago Office, Chile in November, 2010. The number of connected institutions increased by only one by 2012. In 2013, our network expanded to Colombia and Costa Rica with 11 sites in total, and it rapidly increased to 48 institutions in seven countries in Latin America in 2016. Mexico has the largest number of 14 institutions in total, followed by Brazil and Colombia with 11 institutions each (Table 1).

Table 1. Cumulative number of connected institutions/hospitals.

	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Brazil	1	1	1	2	3	5	9	11
Mexico	1	1	1	1	3	9	12	14
Chile	-	1	1	1	1	2	2	5
Colombia	-	-	-	-	3	7	11	11
Costa Rica	-	-	-	-	1	1	2	4
Dominican Republic	-	-	-	-	-	1	1	1
Bolivia	-	-	-	-	-	-	1	2
Total	2	3	3	4	11	25	38	48

3.2 Expanding Programs and Contents. We have organized 46 programs in total during these 8 years. The annual number of programs was up to two until 2012, but it increased from six in 2013 to 17 in 2016. Regarding the total number of connections, there was no more than 3 connections in a year by 2012, but after 2013, it increased rapidly to reach 50 in 2016 (Table 2).

The programs were analyzed according to the content (Fig. 1). Endoscopy accounted for 65% (30/46) of all programs. Technology accounted 11% (5/46), followed by surgery (4%).

Teleconferences accounted for 93% (43/46) of all programs, and 7% (3/46) were live demonstrations (Fig. 2).

Table 2. Total number of connections.

	2009	2010	2011	2012	2013	2014	2015	2016	Total
Brazil	2	0	-	1	3	3	10	7	26
Mexico	1	0	-	-	5	14	9	20	49
Chile	-	1	-	-	3	5	3	9	21
Colombia	-	-	-	-	3	10	8	6	27
Costa Rica	-	-	-	-	1	3	3	7	14
Dominican Republic	-	-	-	-	-	1	1	-	2
Bolivia	-	-	-	-	-	-	3	1	4
Total	3	1	0	1	15	36	37	50	143

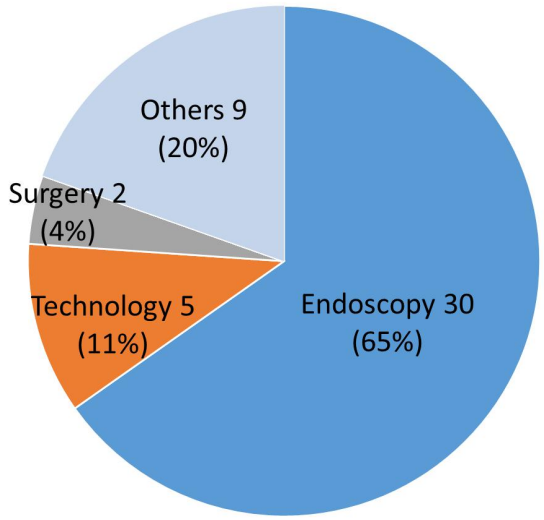

Fig. 1. Program contents

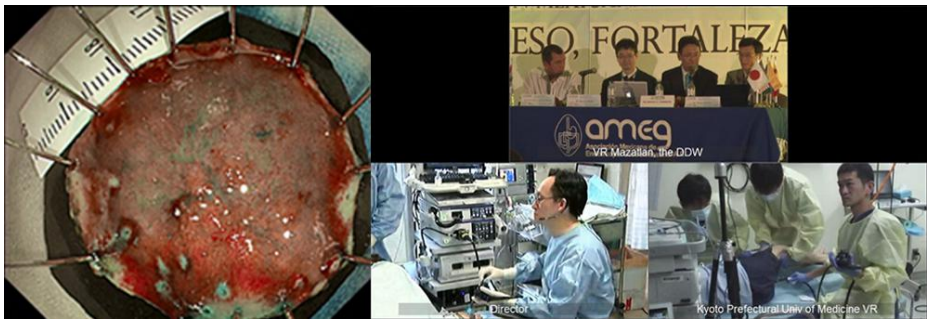

Fig. 2. Scene of live demonstration of endoscopy.
Left: demonstrated endoscopic image. Right: Connected three institutions; main venue at International Conference Center in Mazatlan, Mexico *(top)*, ASAN medical center, Korea *(left bottom)* and Kyoto Prefectural University of Medicine, Japan *(right bottom)*

3.3 Technological Changes. We divided the 8 years into 2 periods, the first and the last 4 years, and compared each category as shown in Table 3. The total number of connections increased drastically by 28 times from 5 to 138, same as newly connected institutions by 11 times from 4 to 44. In the first 4 years, DVTS (50%, 2/4) and H.323 (50%, 2/4) were mainly used as teleconferencing systems. However, the majority turned to Vidyo (74%, 31/42) in the last 4 years. Regarding network, 75% (3/4) of institutions were connected to REN in the first half. However, commercial network (55%, 24/44) surpassed REN (45%, 20/44) with the newly connected institutions in the last 4 years. Regarding the participating institutions, in the first 4 years there was no difference in the university hospitals (2/4, 50%) and non-university hospitals (2/4, 50%), however in the last half, more non-university hospitals (31/44, 70%) were newly connected than university hospitals (13/44, 30%) .

One-way streaming was never carried out in the first half, but it was done in the 12 programs in the last half. The programs was streamed out to 24 institutions in 6 countries, Argentina, Brazil, Chile, Colombia, Costa Rica and Mexico.

3.4 Questionnaires. The answers for the questionnaires were collected from 281, 261, 259, 255 participants for image resolution, image movement, sound quality, and programs, respectively. Image resolution and movement and sound quality were with more than 92% commenting that they were “very good” or “good”. For programs, 98% commented that they were “very good” or “good” (Fig. 3).

Table 3. Comparison between the first and the latter half during 8 years.

		2009-2012	2013-2016
Connected countries		3	7
Number of programs		4	42
Total number of connections		5	138
Systems	**DVTS**	2/4 (50 %)	3/42 (7 %)
	H.323	2/4 (50 %)	5/42 (12 %)
	Vidyo	-	31/42 (74 %)
	Others	-	3/42 (7 %)
Newly connected institutions		4	44
Network at newly connected institutions	**REN**	3/4 (75%)	20/44 (45%)
	Commercial	1/4 (25%)	24/44 (55%)
Types of newly connected institutions	**Univ. hospital**	2/4 (50%)	13/44 (30%)
	Non-univ. hospital	2/4 (50%)	31/44 (70%)
One-way streaming		0	12

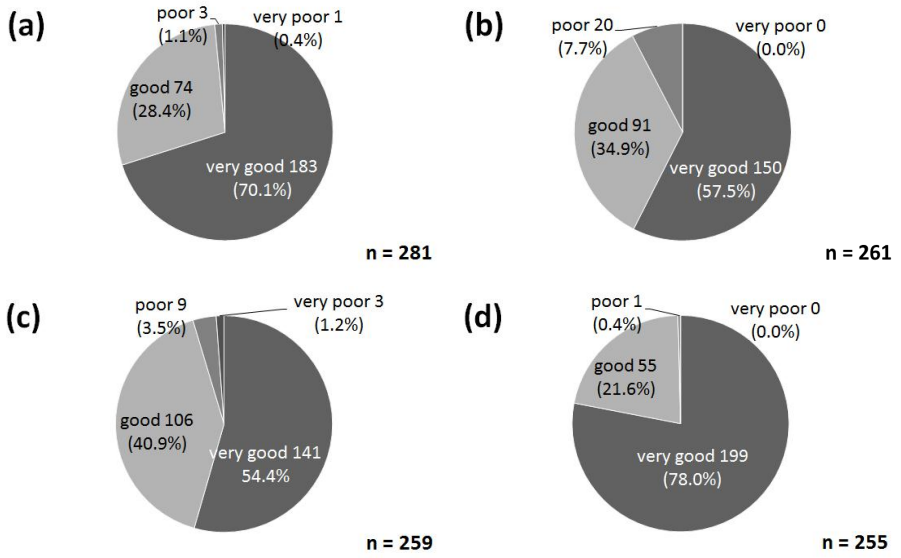

Fig. 3. Questionnaire results on (a) image resolution, (b) image movement, (c) sound quality, and (d) program.

4 Discussions

In this manuscript, we showed that remote medical education had been expanding in Latin America during 8 years. The numbers of participating medical institutions and organized programs dramatically increased with satisfactory image, sound quality and attractive programs for medical education. At the end of 2016, a total of 48 medical institutions and hospitals in 7 countries were our members and 46 programs were performed.

These rapid expansions were achieved mainly during the recent 4 years. Although there had been only 4 participating institutions in 2012, a drastic expansion happened with 44 connecting sites in 2016. In the first half when we used DVTS or H.323, the image quality was not satisfactory for the medical people. One reason is due to the network that was not always stable for DVTS to be transmitted with as big as 30Mbps through Latin American countries, and another is because H.323 used was not HD compatible but only SD at that time. The rapid advancement of our activity is largely ascribed to the big changes and advancement of both network and videoconferencing equipment. Transmitted image quality of HD-H.323 was much better than its old models and was as good as that of DVTS [13]. Emergence of Vidyo accelerated our activity with technical advantage of easy handling without the need of Global/Public IP and cost benefit for the clients without needs of purchasing costly hardware as far as they use our server in Japan [14]. The one-way streaming to watch these programs without joining discussion is technically much easier, and showed rapid increase in number of participants, too. Although live demonstrations need more careful preparations, three demonstrations of endoscopy were successfully performed from Japan all the way to Mexico twice and Colombia once.

One leading program in Latin American countries in this study is to make an early diagnosis of gastric cancer. The incidence of gastric cancer is quite high in Latin America, similar to East Asia like Japan and Korea. Contrary to the similarity of high incidence, the mortality is quite different between the two regions; low in the latter and still very high in the former. So this is why many doctors in Latin America is eager to learn how to diagnose it in early stage so that they can save the patients by adequate treatment without delay. Current reality in Latin America is that most of the gastric cancer patients are diagnosed at an advanced stage, which is too late for curative treatment. Gastric cancer is just an example and we expect to have many more educational needs so that many more hospitals can benefit from the programs.

The limitation of REN is that it connects many universities including medical colleges but it is not always connected to hospitals. Although there are big needs of remote medical education in hospitals especially in rural areas with few medical specialists, the access of REN is not necessarily satisfactory. This is why they must use commercial networks and its ratio has been increasing. But of course, the major medical colleges connected to REN remain the hub of other hospitals where only commercial networks are available because the stability and bandwidth of the network is much better with REN.

Although remote medical education is expanding in Latin America, there are still some problems to be considered. One is that many participating hospitals are in the capital or in major cities in each country, and we should work to invite more hospitals across the country. Also the participating countries are still seven in number and so

more expansion across the region is highly expected. The second is that the program is still limited in Latin America when compared with that in Asia where over 30 subspecialized programs are actively involved. The third is that supporting engineers in the hospitals are not well educated for telemedicine and the systematic training programs for them are essential for the activity expansion and quality control [15].

It is quite useful to take full advantage of ICT in remote medical education between Japan and Latin American countries at the opposite side of the earth, but it is strongly recommended to establish a self-independent team of telemedicine within Latin America to function in their own time frame and to manage their various internal medical problems.

Acknowledgments

This work was supported by JSPS Core-to-Core Program, B. Asia-Africa Science Platforms, KAKENHI Grant Number 15K08556, and 16H02773.

We are grateful to Dr. Jaymel Castillo for English revision.

References

1. Pusponegoro, HD, Soebadi, A, Surya, R: Web-based versus conventional training for medical students on infant gross motor screening. Telemed J E Health. 21(12), pp. 992-997 (2015)
2. Winn, S, McKeown, P, Lotfipour, S, Maguire, GA, Youm, JH, Wiechmann, W, Christian FJ: Remote, synchronous, hands-on ultrasound education. Telemed J E Health. 21(7), pp. 593-597 (2015).
3. Shima, Y, Suwa, A, Gomi, Y, Nogawa, H, Nagata, H, Tanaka, H: Qualitative and quantitative assessment of video transmitted by DVTS (digital video transport system) in surgical telemedicine. J Telemed Telecare. 13(3), pp. 148-153 (2007)
4. Seble, F, Yianna, V, Zohray, T, Nadia, M, Hether, R, Hannah,W, Selam, B, Kristine, K, Abdel, KK, James, S: E-learning in medical education in resource constrained low- and middle-income countries. Hum Resour Health. 11(1) (2013)
5. Shimizu S, Nakashima N, Okamura K, Hahm, JS, Kim, YW, Moon, BI, Han,HS, Tanaka, M. International transmission of uncompressed endoscopic surgery images via superfast broadband internet connections. Surg Endosc. 20(1), pp. 167-170 (2006)
6. Shimizu, S, Kudo, K, Antoku, Y, Hu, M, Okamura, K, Nakashima, N: Ten-year experience of remote medical education in asia. Telemed J E Health. 20(11), pp. 1021-1026 (2014)
7. Ho, SH, Rerknimitr, R., Kudo, K., Tomimatsu, S., Mohamad, ZA, Aso, A, Seo DW, Goh KL, Shimizu, S: Telemedicine for gastrointestinal endoscopy: The endoscopic club E-conference in the asia pacific region. Endosc Int Open. 5(4), pp. E244-E252 (2017)
8. Pinxteren, BV, Topcuoglu, A: GEANT compendium of national research and education networks in Europe. 2014 Edition, pp. 23, Amsterdam, NL: GEANT Association (2014)
9. Minh, CD, Shimizu S, Antoku Y, Torata, N, Kudo, K, Okamura, K, Nakashima, N, Tanaka, M: Emerging technologies for telemedicine. Korean J Radiol. 13 (Suppl 1), pp. S21-S30 (2012)

10. Liu, WL, Zhang, K, Locatis, C, Ackerman, M: Internet-based videoconferencing coder/decoders and tools for telemedicine. Telemed J E Health. 17(5), pp. 358-362 (2011)
11. Ogawa, A, Kobayashi, K, Sugiura, K, Nakamura, O, Murai, J: Design and implementation of DV stream over internet. IWS 99, pp. 255-260 (1999)
12. Fatehi, F, Armfield, NR, Dimitrijevic, M, Gray, LC: Technical aspects of clinical videoconferencing: A large scale review of the literature. J Telemed Telecare. 21(3), pp. 160-166 (2015)
13. Minh, CD, Shimizu, S, Kudo, K, Antoku, Y, Torata, N, Okamura, K, Nakashima N, Tanaka, M: Comparison between digital video transport system (DVTS) and high definition H.323 system in telemedicine. In: Jordanova M, Lievens F, (eds.) Global telemedicine and eHealth updates: Knowledge resources. 5th ed, pp. 310-313, Luxembourg, International Society for Telemedicine & eHealth (ISfTeH) (2012)
14. Kudo, K, Shimizu, S, Chiang, T, Antoku, Y, Hu, M, Houkabe, Y, Nakashima, N: Evaluation of videoconferencing systems for remote medical education. Creat Educ. 5(12), pp. 1064-1070 (2014)
15. Santos, AF, Alves, HJ, Torres, RM, Melo, MCB: Telehealth distance education course in Latin America: analysis of an experience involving 15 countries. Telemed J E Health. 20(8), pp. 736-741 (2014)