Renal Replacement Therapy

REVIEW

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Peritoneal dialysis care by using artificial intelligence (AI) and information technology (IT) in Japan and expectations for the future

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Abstract

In 2022, the government approved the telemedicine system for peritoneal dialysis (PD) in Japan in the form of medical fees. In 2000, we completed a telemedicine system for PD using an automatic peritoneal dialysis (APD) machine. We have published several papers and obtained international patents, but it was impossible to spread them. In recent years, the use of the internet and the spread of COVID-19 have led to the recognition of the importance of telemedicine, leading to the approval of medical fees for telemedicine in PD treatment in Japan. This change is believed to indicate the future direction of PD medicine. However, the current systems are still inadequate. They are difficult to use, and it is difficult for older patients to master their use. Therefore, we hope to develop a system that is easy to use, even for older patients. The new system is a wristwatch or mobile phone monitoring system for blood pressure, heart rate, partial pressure of oxygen, and electrocardiogram. However, development competition for such a mechanism occurs worldwide. Soon, the use of telemedicine in home medical care is expected to become a common practice. It is expected that the telemedicine system, which has been approved for patients using APD in Japan, will also be available for patients undergoing PD other than APD and patients undergoing home hemodialysis in the future. One important feature would be cooperation among doctors, nurses, clinical engineers, medical care teams, and primary care physicians. Advances in artificial intelligence (AI) and information technology (IT) are expected to significantly expand PD medical care in the future. This review is focused on the use of AI and IT for PD medical care in Japan and expectations for the future.

Keywords Information technology (IT), Artificial intelligence (AI), Telemedicine system, Peritoneal dialysis (PD), Home hemodialysis (HHD), Aging society

Introduction

What is the future of medical care for patients with chronic kidney disease (CKD) in Japan? One clear fact in answering this question is that Japan's aging population is steadily increasing. This aging society is likely to become a global problem in the near future. In Japan, the aging of dialysis patients has become an important issue in dialysis medical care. Recently, the average age of dialysis patients at the start of dialysis exceeded 69 years and is expected to reach 70 years shortly. Diabetes mellitus is the leading cause of dialysis in Japan, and the number of patients with complications, including cardiovascular diseases, is increasing. An important issue facing Japan's current medical care is how the medical system will support older patients undergoing dialysis in the future.

"Promotion of a comprehensive community care system" is one of the medical care system policies that Japan is currently promoting. The term "community integrated

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care system" was first used in 2005. In 2005, the "Long-Term Care Insurance Law Revision" was implemented in Japan. This system was planned as a national policy to mitigate the numerous problems expected in the future due to the declining birthrate and aging society. A community-based integrated care system is one in which older patients live at home and are supported by their family members, nearby primary care physicians, and nurses at nursing care stations. Medical care in Japan has traditionally centered on hospitalization. Home medical care is expected to become central in an aging society in the future. Will such a change in the form of medical care not lead to a decline in the level of medical care in Japan?

In Japan, many individuals are looking forward to developing new medical systems that use artificial intelligence (AI) and information technology (IT) to support home medical care.

Beginning of clinical application of IT in dialysis medicine and progress of IT

The implementation of IT in recent years has been remarkable, and "IT" has become a word that most Japanese people understand. IT and the internet have become integral parts of our daily lives. In Japan, with the advent of 5G (fifth generation network), the spread of IT is not limited to the living environment but to a wide range of industries such as agriculture, forestry and fisheries, service, manufacturing, and financial industries.

Moreover, many IT-related technologies have been incorporated into the medical industry. For example, telemedicine has been implemented and is widely used in clinical practice. Remote medical consultations in clinical applications, especially image-related diagnosis and clinical pathology diagnosis, are used in clinical settings via the internet. As advocated by the Cabinet Office, 5G is a communication infrastructure that will play an important role in realizing Society 5.0, and there are high expectations for telecommunications carriers that provide it. In addition, the emergence of new service providers, such as local 5G and infrastructure sharing, could bring about major changes in the environment surrounding the telecommunications industry. In the field of dialysis medicine, changes in the internet environment have brought about major changes to home medical care, especially in PD. Moreover, telemedicine has also been introduced into the PD process, and our group was the first in the world to initiate telemedicine for PD.

In 2000, we developed a PD monitoring system for home patients using telephone lines and published several papers (Fig. 1) [1–7]. We also obtained Japanese and international patents for the PD telemedicine system. At that time, the spread of the internet network system in Japan was insufficient. Figure 1 shows an overview of the monitoring system for home PD using an automatic peritoneal dialysis (APD) device. The patient's condition was monitored by videophone using the Picture Archiving and Communication System (PACS) that became available at that time. Moreover, the PD fluid injection volume, drainage fluid volume, and water removal volume were continuously monitored using the APD machine (Fig. 2). Body weight and blood pressure were also monitored using scales and sphygmomanometers, which were connected using a telemedicine system (Fig. 3). These data were confirmed by doctors and nurses located at a distance of 100 km or more, if any abnormalities in the data were confirmed, the doctors and nurses used the telephone to confirm with the patient. In addition, if necessary, the patient could change the PD process performed by the APD [1–4]. In fact, in 2000, a 90-year-old woman underwent PD using APD at home, and her PD data could be shared for 1 year through a telemedicine system (Fig. 4).

Subsequently, we expanded the application of this system to mobile phones and broadband and developed a mechanism that can continuously monitor blood pressure, blood sugar, weight, etc., at home (Fig. 5). Using these mechanisms, Japanese guidelines have been revised to measure blood pressure at home for the management of hypertension in Japan [5–7].

Such a system is currently being carried out in Japan by Baxter's APD device, "Home PD System Kaguya" Patient data were shared through a program called Sharesource. These data can now be shared by attending physicians, nurses, and patients themselves. Home management of patients undergoing PD using this Sharesource (PD treatment planning program) has been reported to significantly reduce the number of emergency outpatient and home visits of these patients [8, 9].

Twenty years later, we developed a patient management system using telemedicine, published a paper regarding this, and acquired a patent. It was first used by general patients in Japan. In today's society, where the internet has become commonplace, such a system is now available to general patients. We are happy about this situation, but when we announced our system, it was too early for the world to follow.

Telemedicine reimbursement for home PD has been approved in Japan

In the 2022 revision of medical fees in Japan, an addition to medical expenses for remote monitoring was approved in the treatment of patients with PD. When a patient undergoing PD attaches a monitoring function to an APD device at home and performs remote monitoring at a medical institution, it is possible to obtain 115 points (1150 yen) of remote monitoring costs as medical

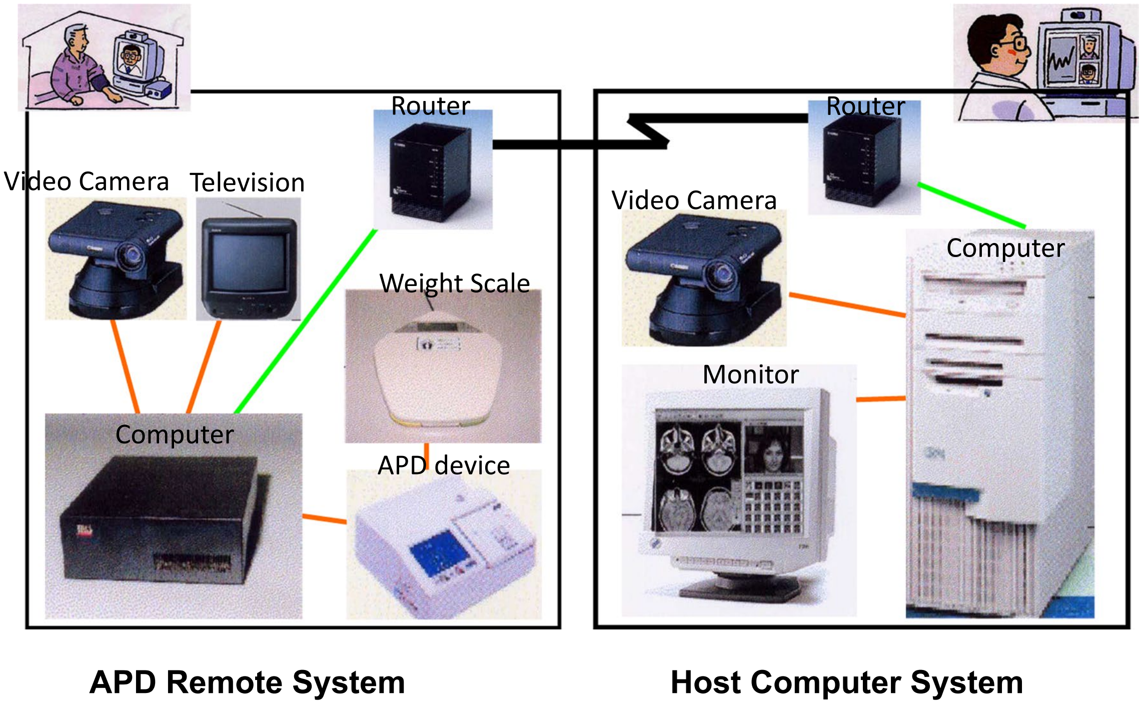

Fig. 1 Ver 1.0 of the newly developed telemedicine system for patients undergoing continuous ambulatory peritoneal dialysis using automatic peritoneal dialysis. The patient side performing PD consists of a videophone system using a video camera and television, and a weight scale and an APD device. These are connected to a computer and transfer data through a router to the doctor's side. Physicians continuously monitor the patient's condition through computers and video monitors

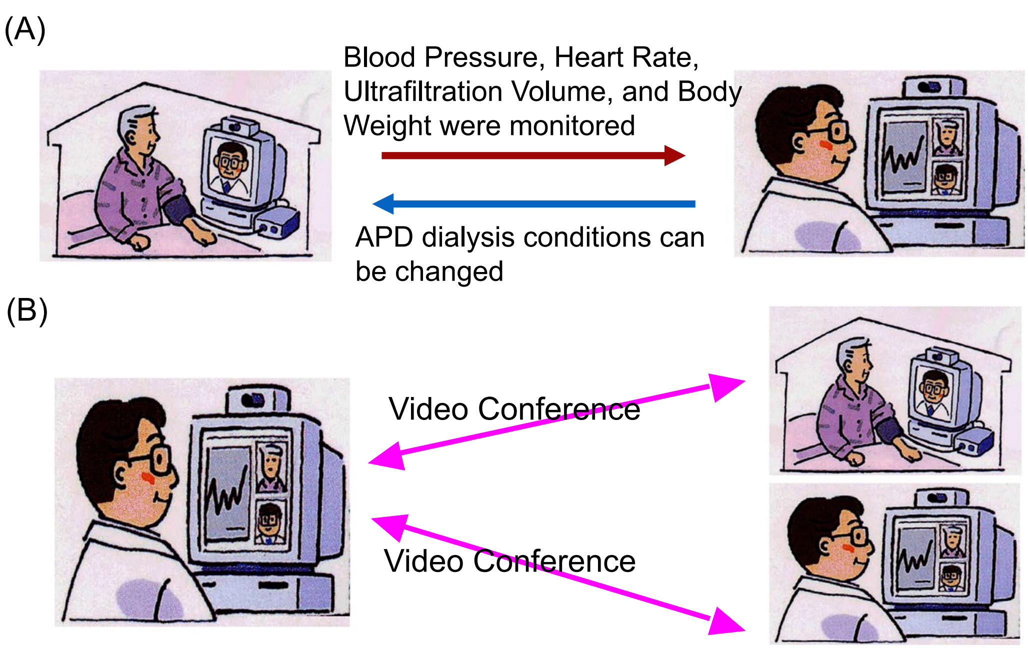

Fig. 2 Home automatic peritoneal dialysis monitoring system. Using this telemedicine system, it is possible to monitor the data of patients undergoing peritoneal dialysis (PD) and change dialysis conditions when necessary. Furthermore, using a videophone, it is possible to have a conversation with a patient undergoing PD

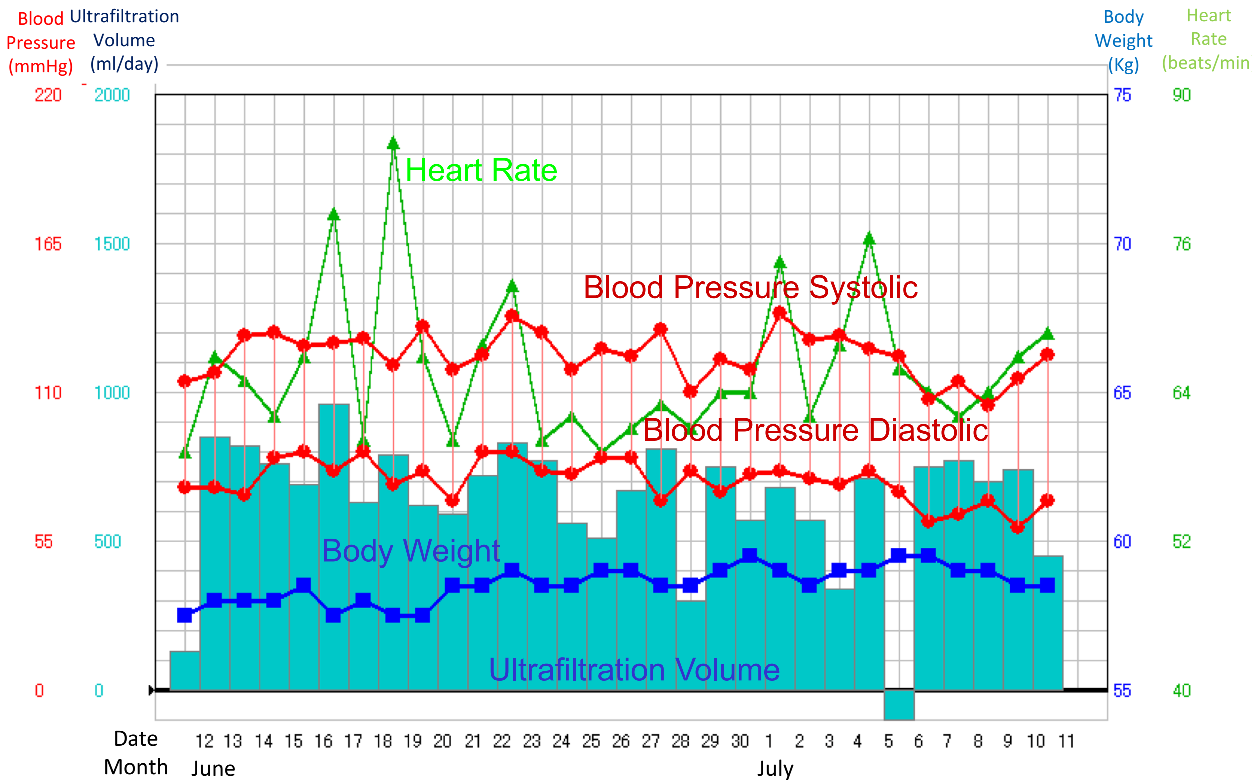

Fig. 3 Body weight and blood pressure were also monitored using weight scales and sphygmomanometers, which could be shared using a telemedicine system

Fig. 4 A 90-year-old woman undergoing peritoneal dialysis using the telemedicine system

expenses only once a month. The following conditions must be met to qualify for telemedicine: (1) continuous monitoring of conditions such as the amount of PD fluid injected, the amount of PD fluid discharged, the amount of water removed, body weight, blood pressure, and body temperature by using the information communication

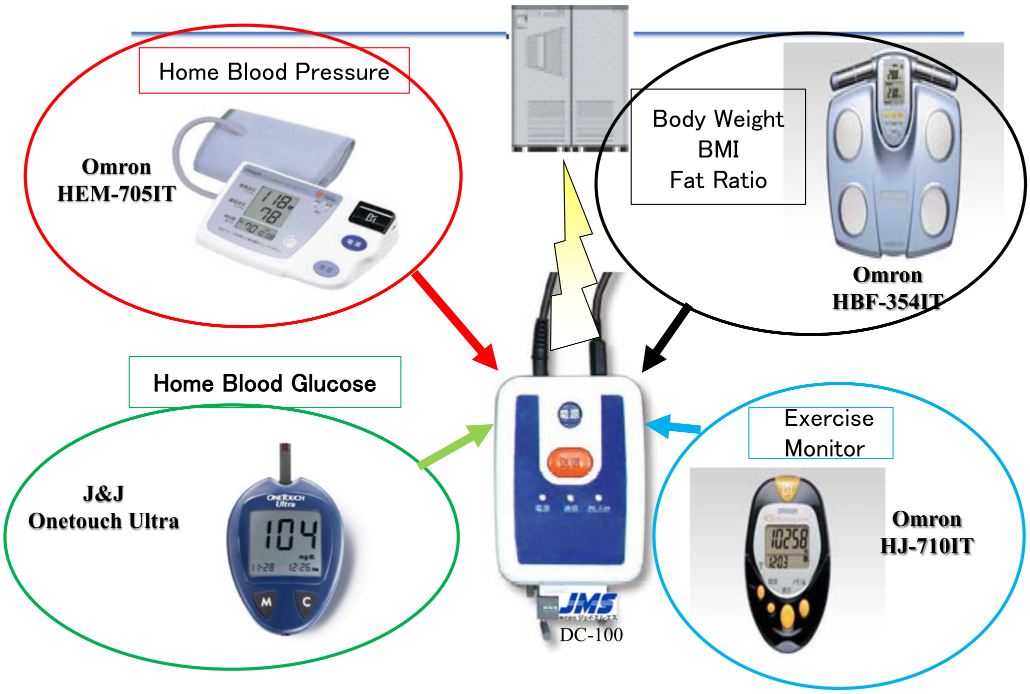

Fig. 5 An internet-based home blood pressure, blood sugar, exercise dose, and body weight monitoring system. By expanding the application of this system to mobile phones and broadband networks, we have developed a system that enables continuous monitoring of blood pressure, blood sugar, weight, etc., at home. The JMS DC-100 is a small, portable router that transmits measurement data from each instrument to a base station computer database via USB. Blood pressure is connected to a blood pressure monitor (Omron HEM-705IT) via USB, and the blood pressure data are sent to the computer database of the base station. In addition, the weight is connected to a weight scale (Omron HBF-354IT) to transmit weight data. Exercise therapy connects with a pedometer (Omron HJ-701IT) and transmits daily step count data. And the blood sugar connects to a blood sugar meter (J&J Onetouch Ultra) and sends blood sugar data

device installed in the APD; (2) depending on the monitoring situation, it is necessary to take appropriate measures, such as prompting the patient to visit a clinic, if there is any abnormality in the patient's condition; (3) in the month in which these additions are calculated, the findings obtained from monitoring the contents of guidance and management are to be recorded in the medical records, and (4) monitoring is to comply with the "Guidelines for Safety Management of Medical Information Systems" stipulated by the Ministry of Health, Labor, and Welfare.

Currently, in Japan, Baxter's APD is the only PD equipped with a communication device for data transfer. In addition, by using a Sharesource, all data can be shared among doctors, nurses, and clinical engineers. It is also possible to cooperate with family doctors during emergencies. Moreover, it is possible to remotely change the settings of the Home PD System Kaguya for home patients. Using this system, telemedicine for the elderly is possible, leading to benefits for patients.

In Japan, due to the ongoing COVID-19 epidemic, many patients want to refrain from going to hospitals as much as possible. Under these circumstances, when a doctor treats a patient with a chronic disease using a telephone or an information communication devices and prescribes medicine, the medical institution covered by insurance for the payment system, it is possible to requests to pay the re-examination and prescription fees. In dialysis medical care, the current target patients are patients undergoing PD who have calculated the home-care guidance management fee within the past 3 months. Physicians provide medical care using telephones and information communication devices and give proper attention and guidance to patients or those taking care of patients concerning matters necessary for medical treatment, as well as necessary and sufficient amounts of sanitary materials or insurance. When medical materials are provided, home-care guidance management fees and material additions can be calculated. Although this is an emergency response to the COVID-19 epidemic, telemedicine may be permitted through the use of shared sources in the future [10, 11]. This trend aligns with the direction of proactively applying AI, IT, and robotics to clinical applications to actualize work-style reform in Japan.

Currently, in Japan, PD manufacturers other than Baxter do not have APD equipment to support remote diagnosis. For this reason, Terumo Co. and JMS Co. are also planning to announce APD devices that are compatible with telemedicine within this fiscal year.

Revolution in dialysis medical care due to advances in AI and IT technology

The steady progress of computers has led to significant advances in the medical field. For example, in the distribution industry, Amazon Co., Alibaba Co., and Rakuten Co. make it easy to purchase all sorts of goods at low prices. Many supermarkets and department stores went bankrupt due to customers being able to purchase everyday foods and miscellaneous goods without going to the stores. Currently, many individuals are familiar with the internet and can access almost anything from their homes. This internet revolution has occurred worldwide, especially in the industrial sector, and has brought about greater changes than the industrial revolution that occurred in the UK more than 100 years ago.

In medical care, data are constantly exchanged between patients and medical personnel. Much information is exchanged among manufacturers, health organizations, patients, and medical personnel. Regarding this exchange, IT can play a significant role. A typical example is the introduction of electronic medical charts to the medical field. In Japan, partly due to government subsidies, more than 80% of large hospitals have introduced electronic medical records. Further revolutionary changes are expected in the medical field [10, 11]. The most anticipated changes are: (1) changes to home medical care due to advances in telemedicine (data collection, monitoring, etc.); (2) telemedicine and dialysis management using remote systems; (3) diagnosis and treatment using AI as it progresses; (4) medical care combining robots and AI; (5) home care using robots and AI, and (6) complete management system using AI for home dialysis, among others. Combining these with advances in electronic engineering, we can expect unpredictable developments in medical care in the future. Recently, junior high school students devised a nursing care system using virtual reality technology. The system used virtual reality to create a virtual space where a loved one would be on the older patient's side, taking care of them.

The optimal form of an AI-based dialysis management system is a home dialysis management system that uses AI and dialysis robots. Several ventures have had similar considerations. It can be concluded that dialysis medicine is the field that AI and robot technology are most likely to enter. Calculating appropriate dialysis conditions for patients, control of water removal, and dialysis based on body weight and blood pressure fluctuations will soon be clinically applicable as dialysis control systems. To this end, industry-academia collaboration with Japanese medical device manufacturers is essential. In order to develop future dialysis processes through collaboration between AI, IT, and the robotics industry, it is important to build a system based on sufficient industry-academia collaboration. For that purpose, it is essential to collect a lot of data on dialysis medical care, so-called big data. We hope that the construction of a new collaborative system of IT, AI, and robot industries will greatly contribute to medical care, and that dialysis medical care in Japan will make great progress in the future.

Abbreviations

CKD	Chronic kidney disease
PD	Peritoneal Dialysis
AI	Artificial Intelligence
IT	Information Technology
APD	Automated Peritoneal Dialysis
COVID-19	New coronavirus disease
PACS	Picture Archiving and Communication System

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Author contributions

HN was responsible for the conception, design, and final approval of this article. RA, TK, TK and MR were responsible for the critical revision of the article for important intellectual content. All authors read and approved the final manuscript.

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Availability of data and materials

Data sharing not applicable to this article as no data-sets were generated or analyzed during the current study.

Declarations

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Not applicable.

Consent for publication

Not applicable.

Competing interests

Hidetomo Nakamoto: receives research funding, lecture fees, writing fees, and other remuneration from Toray Industries Inc. (manufactures and sells pharmaceuticals and medical products), Kissei Pharmaceutical Co. (research, develops, manufactures, and sells pharmaceuticals), Boehringer Ingelheim International GmbH (manufactures, sells, and imports pharmaceuticals), Terumo Corp. (manufactures and sells medical devices and pharmaceuticals), Astellas Pharma Inc. (manufactures, sells, imports, and exports pharmaceuticals), JCR Pharmaceuticals Co. (manufactures and sells raw materials for pharmaceuticals; imports and exports medical devices), Kyowa Kirin Co. (manufactures and sells prescription drugs), and Chugai Pharmaceutical Co. (manufactures and sells prescription drugs). Ryutaro Aoyagi, Takeru Kusano, and Takehito Kobayashi have no competing interests to disclose. Munekazu Ryuzaki: receives travel expenses for participating in academic conferences and other events from OMRON Corp. (manufactures and sells medical equipment).

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