Original Article

The Implementation of Teleneurosurgery in the Management of Referrals to a Neurosurgical Department in Hospital Sultanah Amninah Johor Bahru

Risdhawati Hassan[1,2], Johari Adnan Siregar[1,2], Noor Azman A.Rahman@Mohd[1,2]

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[1] *Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia*

[2] *Department of Neurosurgery, Hospital Sultanah Aminah Johor Bahru, 80100 JohorBharu, Malaysia*

Abstract

Background: **Telemedicine in neurosurgery or teleneurosurgery has been widely used for transmission of clinical data and images throughout the country since its implementation in 2006. The impact is a reduction of patient number that need to be reviewed in the level III hospitals and an increment in the number of patients that are kept in level II hospitals for observation by the primary team. This translates to reduction of unnecessary transfer of patients and subsequently cost benefits for patients and medical providers. The main aim is to determine the amount of reduction in unnecessary transfer by the implementation of teleneurosurgery in the management of referrals to neurosurgical department in Hospital Sultanah Amninah Johor Bahru (HSAJB). Other factors associated with transfer decision are also evaluated.**

Methods: **This prospective cohort study was conducted in HSAJB, Johor over four months. A total of 349 subjects referred to HSAJB are included with 12 subjects excluded. The subjects are followed up from the time of referral until three months post-referrals. Related data includes the decision before and after reviewing the radiological images on teleconsultation website with clinical data available.**

Results: **There was a significant reduction in the number of inter-hospital transfer. 37% of transfer is avoided and patients are best kept in their original hospitals. However, there are additional findings in which there are 20.1% of patients that thought does not require transfer based on clinical data alone, would have to be transferred when the clinical data and images are reviewed. This translates to an increment of 20.1% need to be observed in neurosurgical center. Without the images, these patients might be observed in the referral hospitals with higher risk of deterioration. Other factors that are related to transfer decision apart from images include Glasgow Coma Scale (GCS) and diagnosis. The GCS significantly associated with transfer when only clinical data is reviewed. However, in situation where clinical data and images are reviewed together, the GCS and diagnosis are significantly associated with transfer decision. On multi-factorial analysis, more of mild head injury being transferred for observation in neurosurgical unit after images and clinical data reviewed which correlates to an increment from 1.85% to 3.9%. Another finding is reduced of risk of patients transferred for trauma from 1.85% to 0.519% after the data reviewed.**

Conclusion: **Teleneurosurgery is beneficial in the management of referrals from level II hospitals. The inter-hospital transfer is significantly reduced, however there is an increased in the number of patients that need to be observed in neurosurgery unit for the risk of potential deterioration.**

Keywords: *teleconference, remote consultation, neurosurgery, craniocerebral trauma, coma, post-head injury*

Introduction

The structure of government hospital in Malaysia are divided into three levels. Level I consist of primary and secondary healthcare centres where no specialist services are available. Level II consists of tertiary healthcare centres with basic specialties available but without neurosurgeon onboard. Level III consists of tertiary healthcare centres with additional sub-specialties including neurosurgery. Teleneurosurgery is the use of communication technologies to transfer medical information related to neurosurgery. It was introduced gradually in government hospitals

throughout Malaysia in 2006. By 2012, there were five centres with neurosurgical services operating on this system. The system consists of three sites which are sender, receiver and the centres for the system monitoring and data archiving located in Putrajaya. The minimum software requirement is Microsoft Windows™ 2000. Each site is connected using integrated services digital network (ISDN) lines. Images are managed and viewed by picture archiving and communication system (PACS) while clinical and other written information is managed through the standard Digital Image Communication in Medicine (DICOM). The sending site consists of few components: computer,digitizer for image digitising and printer for record. The receiver site consists of the PACS viewer, computer and printer. Each consultation could also be accessed by any personal computer, however the image is displayed in Joint Photography Experts Group (JPEG) format with a poorer resolution. Any transmission failure will be alerted to Putrajaya through telephone call or TeleNeurosurgery website. Rectification process will be done as soon as possible or in the next working days.

Neurosurgery department in HSAJB provide services in areas around Johor and southern area of Malacca. However, only 2 out of 9 hospitals in Johor were equipped with the teleneurosurgery equipment and computed tomography (CT) scan facility. Prior to the availability of this system, these two hospitals were referring patients using telephone conversation with direct casualty admission for CT brain with or without ward admission depending on clinical and images reviewed directly in HSAJB, casualty department. This referral mode has many flaws in term of communications, especially conveying an unreported CT brain images and lack of data archiving for medico-legal documentation. Many patients with the suspected neurosurgical pathology will have to be sent to the level III hospitals, however, admission is not guaranteed if patients are sent back to their respective hospital after clinical and imaging assessment.

In the early 1990s, teleradiology was established using conventional personal computer. Dohrmann (1) reported that teleradiology was a simple and effective means of transmitting valuable clinical data within or between the hospitals and between hospitals to individuals which markedly enhanced the quality of clinical communication. Lee (2) noted that the system had led to substantial improvement in the management of neurosurgical emergency referrals, cost effectiveness of neurosurgical and ambulance facilities, and inter-hospital communication between doctors. In the beginning of 20th century, the teleradiology system was well established. Complete cranial CT scan was possible in 3 to 4 minutes. Stormo et al. (3) reported that teleradiology has managed to remove the potential need for courier services. Crocker et al. (4), reported the use of image link was associated with fast and good image transfer quality, but at times might be unreliable due to delay from modem connection interruptions. Bailes et al. (5) reported that NeuroLink system had led to a more appropriate transfer of patients to a tertiary facility with significant estimated cost savings.

In Malaysia where 44% of the population resides in rural area, the priority is for the rural people to get fair access to the health system as the other urban population counterparts. In the initial phase, teleconsultation in neurosurgery was tied with teleradiology until the introduction of Teleneurosurgery in 2006 to cater specifically for neurosurgery. In 1999, as reported by Abdullah et al. (6) discussion was established on neurosurgical diseases between Neurosurgery Department Hospital Universiti Kebangsaan Malaysia, (HUKM) and the University of Hokkaido, Japan using mailing and facsimile services. Houkin et al. (7) noted that the cost performance of teleradiology service was almost equal to that of the conventional mailing system. The most remarkable advantage was the high quality of transferred images, cost and time performance, and security of the medical information. Other mode used in teleconsultation includes video consultation with comparable accuracy to teleradiology, but slightly higher cost. Wong et al. (8) noted that difference in consultation modes did not have any impact on transfer rate and safety. The other mediator for teleradiology is multimedia messaging system (MMS). However, with MMS, Ng et al. (9) noted that the transmitted images has a lower quality in terms of its resolution. The images were also transfered within an unsecured public network which add to its unfavourable usage. On the other hand, Pirris et al. noted that MMS is a legitimate method for close outpatient observation by neurosurgeons (10). A study conducted by Yamamoto et al. (11) demonstrated a satisfactory image quality with short viewing time although not always perfect reliability of internet connections. Narenthiranathan et al. (12) reported that by 2011, teleneurosurgery service has gained its momentum, as evidenced by the large volume of cases channeled through the system and, also has proven its significance as a

means to provide wide medical coverage within the area.

Eljamel and Nixon (13), Moya et al. (14), Goh et al. (15) and Stormo et al. (3) reported that regardless of the mode of images and clinical data transfer, various studies have concluded the benefits of image transfer in reducing the transfer rate with the range between 20% to 40%. Mrak et al. (16) reported that telemedicine had saved a total of 400 000 km of ambulance travelling distance in Croatia over the span of three years. The outcome of neurosurgical patients that are kept in peripheral hospitals are largely unknown and this made even worst with the lack of follow-up. Servadei (17) reported that the lack of follow-up for patients not admitted to neurosurgery is the limitation on a quality assessment of the system. Patel et al. (18) demonstrated in their study that patients with severe head injury treated only in non-neurosurgical centres were associated with a 26% increased in mortality and a 2-15 fold increased in the odds of death compared with patients treated at a neurosurgical centres. This data contribute to current guidelines, suggesting that treatment in a neurosurgical centres represents an important strategy in the management of severe head injury. A patient with mild to moderate traumatic head injury and positive CT scan, neurosurgical intervention was not recommended, a study done by Fabbri et al. (19) showed that observation in peripheral hospitals with neurosurgical consults by teleradiology system, repeat CT scanning and transfer time 30 to 60 minutes to a neurosurgical unit was not detrimental for subjects with initial non-neurosurgical lesions after mild-moderate head injury. A prospective study by Zulu et al. (20) on the outcome of patients managed conservatively in general surgical unit showed that it was an acceptable practice with outcome determined primarily by the GCS on presentation, and patients managed in neurosurgical unit had a significantly higher mortality rate. A survey by Dunn et al. (21) showed despite of the modernisation in treatment of patients with head injury, complications do occur during inter-hospital transfer, these include hypoxia (6%), hypotension (15%) and missed or inadequately treated extracranial injury (29%). Another survey done by Price et al. (22) revealed significant lapses in the management of critically ill head-injured patients that were transferred to level III trauma center.Walcott et al. (23) suggested that neurosurgery evaluation via telemedicine may be one strategy to improve air transport triage.

Materials and Methods

This was a prospective observational cohort study conducted from November 2011 through February 2012. Three hundred and forty nine subjects across all age group were admitted to Hospital Batu Pahat (HBP) and Hospital Pakar Sultanah Fatimah Muar (HPSFM) with a suspected neurosurgical pathology requiring neurosurgery consultation done using the TeleNeurosurgery system to HSAJB. It was mandatory that all the required information in the system was filled in and relevant images were attached in DICOM format using the digitiser. Inclusion criteria includes; 1). First or new referral, 2). If first referral was excluded, the subsequent referral fulfilling the inclusion criteria would be included, 3). Minimum required information was filled in the clinical data sheet, 4). Relevant images for decision making are attached with the clinical information. Exclusion criteria includes; 1). Teleconsultation referrals were incomplete either with the clinical data or images, 2). Other modes of referrals or image acquisition were being used either through multimedia messaging services (MMS) or e-mail, 3). Poor image quality make the interpretation of images difficult by neurosurgery site, 4). Follow-up consultation. A total of three hundred and sixty one subjects were identified and 12 subjects were excluded. Eight subjects were excluded because of transmission errors while four other subjects were excluded because the information in the data sheet were incomplete. The study sample was calculated based on the previous study by Moya et al (14). In this study, the probability that the teleconsultation failed to meet its purpose is 64%. The study needs at least 306 subjects with matched control per subject to be able to reject null hypothesis and the odds ratio equals to 1 with probability (power of study) 80%. A non-random chance sampling was used from the November'1st 2011 until the required sample size was achieved.

The suspected neurosurgical pathology included were both traumatic and non-traumatic brain injury. The medical officer and specialist on call as the respondent need to fill in the questionnaire for question A and B. Question A requires the respondent to decide whether a transfer of the referred patient to the nearest neurosurgical unit is necessary based only on the available clinical information sent or, not necessary if patients could be managed in the referring hospitals without transfer or, patient need to be seen in neurosurgical unit as an elective basis. Question B requires the respondent to

decide whether the transfer is still necessary after reviewing the available clinical information and the relevant images sent in the teleconsultation web-site. The answer is yes if the patient still need to be transferred and otherwise no if otherwise. The decision was primarily undertake by the specialist on call and a reply form is filled at the end of the process in the teleconsultation web site for documentation of the management decision. Subsequently, the primary investigator will take over the duty of completing the study proforma.
The statistical analysis used for this study design is McNemar and chi-square tests. The data was taken twice for every subject that equals to dependent sampling or related sampling. chi-square test and independent t-test was chosen to test the significance differences between two variables. The assumption was fulfilled because the data is random, independent, and the expected frequency < 5 was less than 20% of the cells. The other factors that affect the transfer decision will be calculated and predicted based on simple logistic regression.

Results

Table 1 showed the association between inter-hospital transfer based on clinical data alone or clinical data and images (P < 0.05). Therefore, null hypothesis is rejected and the difference between variables is significant. Number of inter-hospital transfer based on clinical data alone is significantly difference with number of inter-hospital transfer based on clinical data and images. In this data analysis, unnecessary transfer can be avoided in 37.1% of the study subjects. Table 1 also showed that 20.1% of the study subjects that need to be transferred were kept in the peripheral hospitals by only reviewing the clinical data. This means those patients were considered unnecessary for transfer is actually need to be transferred when images were reviewed. The correct decision on transfer despite not looking at the images is 62.9% for transferred patients and 79.9% for those that were kept in the Level II hospitals. Table 2 and Table 3 shows the variables may influence the transfer decision namely Glasgow Coma Scale (GCS), diagnosis either trauma or non-trauma, gender, time of referral either outside or within office hour, age distribution and hospitals either HBP or HPSFM. The significance of each variable was tested using chi-square and among all the variables, the GCS was consistently significant in altering the transfer decision whether clinical data alone or clinical data and image were being reviewed ($P < 0.05$). However, for the diagnosis variable, it was not significant when only clinical data was reviewed ($P = 0.461$) and it became significant when clinical data and images were reviewed ($P < 0.05$). Both table 2 and table 3 shows the simple regression analysis of the variables that correlates with transfer decision. If only clinical data was reviewed, moderate GCS group has 0.051 less likely chance of not being transferred (OR 0.051, 95% CI: 0.02, 0.13) compare to severe group while mild GCS category has 0.079 less likely chance of not being transferred (OR 0.079, 95% CI: 0.031, 0.02) compare to severe group. If both clinical data and images were reviewed, mild group has a 3.668 chance to be retained in the referring hospital (OR 3.668, 95% CI: 2.053, 6.554) compare to severe group. Moderate GCS was not significantly affecting the transfer decision. The trauma group has 2.12 higher chance of not being transfer (OR 2.12, 95% CI: 1.321, 3.401) compare to the non trauma group when both clinical data and images were reviewed. On multiple logistic regression analysis, a person in mild category has 3.9 times the chance of not being transferred compared to severe category when only clinical information were reviewed (B: 1.368, OR: 3.929, 95% CI 0.268, 5.746, $P < 0.005$) while a person in mild category has 1.85 times the chance of not being transferred compared to severe category when both clinical and images were reviewed (B: 0.614, OR: 1.847, 95% CI 1.383, 2.467, $P < 0.005$). In another words, when only the clinical data is being reviewed, the mild category was likely to be kept in the Level II hospitals compare to when the clinical data and images were reviewed.

Another significant finding from the linear

Table 1: Association between inter-hospital transfer based either on clinical data or clinical data and images

Variable	Clinical data and images *n* (%)		*P* value
	Transfer	Not Transfer	
Clinical data			
Transfer	44(62.9%)	26 (37.1%)	0.001
Not transfer	56 (20.1%)	223 (79.9%)	

logistic regression analysis is the diagnosis category, when applied to multiple logistic regression analysis, a person in trauma category has 0.519 times the chance of being transferred compared to the non trauma category when only clinical information were reviewed (B: 0.656, OR: 0.519, 95% CI 0.275, 0.979, P = 0.043). When both clinical data and images were reviewed, a person in trauma category has 1.85 times the chance ofnot being transferred compared to non trauma category (B: 0.614, OR: 1.847, 95% CI 1.124, 3.034; P = 0.015). Therefore, when only clinical data were reviewed, most of patients in trauma category would likely to be transferred but when both clinical and images were reviewed, patients in trauma category would likely to be kept in the respective level II hospitals for further management.

On multiple logistic regression analysis, mild head injury category is likely to be kept in the level II hospitals compared to severe group but the chances of being transferred were differed in either situation, 3.9 times compared to 1.85 times chances of being kept in the respective hospital when only clinical data and clinical data and images were reviewed respectively. This might correlates to the 20.1% increase in transfer rate from McNemar test in table 1. For the diagnosis

Table 2: Differences between variables on transfer decision when only clinical data is reviewed

Variables		Transfer status *n* (%)		X^2 value (df)	*P* value	Regression coefficient (B)	Crude Odds Ratio (95% CI)	Wald Statistics	*P* value
		Transfer	Not transfer						
GCS				60.880 (2)	0.01				
	Severe	36 (41.9)	50 (58.1)			0	1		
	Moderate	26 (31.7)	56 (68.3)			−2.973	0.051 (0.02,0.13)	40.08	< 0.001
	Mild	6 (3.6)	163 (96.4)			−2.535	0.079 (0.031,0.20)	28.04	< 0.001
Diagnosis				0.543 (1)	0.461				
	Non Trauma	24 (18)	109 (82)			0	1		
	Trauma	46 (21.3)	170 (78.7)			0.206	1.229 (0.710,2.128)	0.542	0.462
Gender				1.696 (2)	0.428				
	Male	53 (21.3)	190 (78.2)			0	1		
	Female	17 (16.2)	88 (83.8)			−0.367	0.693 (0.379,1.264)	1.431	0.232
Time				0.890 (1)	0.346				
	Outside office hours	44 (21.8)	158 (78.2)			0	1		
	Within office hours	26 (17.7)	121 (82.8)			−0.259	0.772 (0.450,1.323)	0.887	0.346
Age				2.443 (2)	0.295				
	≤ 12	2 (8)	23 (92)			0			
	12–65	49 (21.2)	184 (79)			−1.167	0.311 (0.071,1.362)	2.401	0.121
	≥ 65	19 (20.9)	72 (79.1)			−1.113	0.328 (0.071,1.528)	2.014	0.156
Hospital				3.641 (1)	0.056				
	HBP	39 (24.5)	120 (75.5)			0	1		
	HPSF	31 (16.3)	159 (83.7)				1.667 (0.983,2.826)	3.6	0.058

category, trauma and non trauma groups, patients in trauma group were likely to be transferred compared to non trauma group when only clinical data were reviewed which was 0.519 times higher chance, this chance however change to not being transferred when both clinical data and images were reviewed which is 1.85 times compared to severe category. This correlated to the 37.1% of avoidance of transfer in McNemar test in table 1.

Discussion

The information technology evolves all over the world, the field of telemedicine also changes according to the recent advances. Initially in early 1990s, teleradiology is established using conventional personal computer. This is simple and effective means of transmitting valuable clinical data from hospital to hospital, and hospital to individual, markedly enhancing the quality of clinical communication (2). In Pennsylvania, USA, a NeuroLink system was implemented in 1993. It was a wide-area teleradiology network for delivery of specialty care in neurologic surgery at Allegheny General Hospital (AGH). This has led to more appropriate transfer of patients to a tertiary facility and significant estimated cost savings (3). The beginning of 20th century, teleradiology system was well established in certain places. Complete cranial CT scan was possible in 3–4 minutes. The archiving of image data, establishment of internet access through World Wide Web and a standardized DICOM format for electronic images and PACS to replace film records of patient images have enabled rapid electronic image transfer to the tertiary centre. This removes the potential need for courier service and reduces the time needed for formulation of management plans. In the UK, the introduction of PACS system causes the usage of image link to

Table 3: Differences between variables on transfer decision when both clinical data and images are reviewed

Variables		Transfer status *n* (%)		X^2 value (df)	*P* value	Regression coefficient (B)	Crude Odds Ratio	Wald statistics	*P* value
		Transfer	Not transfer						
GCS				22.27 (2)	< 0.001				
	Severe	38 (44.2)	48 (55.8)			0			
	Moderate	30 (36.6)	52 (63.4)			0.316	1.372 (0.739, 2.548)	1.004	0.316
	Mild	30 (17.8)	139 (82.2)			1.3	3.668 (2.053, 6.554)	19.265	< 0.001
Diagnosis				9.875 (2)	0.002				
	Trauma	51 (38)	82 (61.7)			0	1		0.457
	Non-Trauma	49 (22.7)	167 (77.3)			0.751	2.12 (1.321,3.401)	9.698	0.002
Gender				1.564 (2)	0.457				
	Male	74 (30.5)	169 (69.5)			0	1		0.561
	Female	26 (24.8)	79 (75.2)			-0.286	0.752 (0.447,1.265)	1.115	0.282
Age (years)				5.793 (2)	0.159				
	≤ 12	2 (8)	23 (92)			0	1	5.835	0.12
	12–65	72 (30.9)	161 (69.1)			-1.686	0.185 (0.043, 0.805)	5.062	0.024
	≥ 65	26 (28.6)	65 (71.4)			-1.510	0.221 (0.048, 1.011)	3.788	0.052
Hospital				0.117 (1)	0.732				
	HBP	47 (29.6)	112 (70.4)			0	1		
	HPSF	53 (27.9)	137 (72.1)			0.081	1.085 (0.681, 1.728)	0.117	0.732

fall. However, attempts to improve remote access to PACS systems were hampered by different manufacturers' systems in different hospitals across the National Health Service (NHS), software incompatibilities and concerns over data protection issues (4). In Malaysia, teleconsultation in neurosurgery was tied with teleradiology until the introduction of multimodality system in 2006 called TeleNeurosurgery to cater specifically for neurosurgery service. The aim is for the enhancement of quality services in the field of neurosurgery. It is equipped with user friendly features which allow neurosurgeons to access patients data submitted by physicians in effective manner. The number of cases utilising the teleconsultation service according to each department as released by the telehealth service department until September' 26th 2011: Neurosurgery: 9030, Radiology: 2952, Dermatology: 774, Cardiology: 245 and General: 23. Neurosurgery has basically dominated the service reflecting the higher dependency on the system. According to local study by Narenthiranathan et al, the TeleNeurosurgery service has gain momentum as evidenced by the large volume of cases channeled through the system which proves its significance as a means to provide wide medical coverage within the region (5). Other mode of teleconsultation that are used includes video consultation which involves the direct visual image of patients or any relevant images. The accuracy of video consultation is comparable to the teleradiology, but at slightly higher cost compares to teleradiology. The telephone consultation is lower in term of accuracy. However, difference in consultation modes did not have an impact on transfer rate and safe (6). The other means of image teleconsultation is using the (MMS). The system uses a mobile phone with video graphic array camera and MMS capabilities to assist in the diagnostic process and implementation of emergent clinical therapy. The main drawback is the transmitted images are generally of low resolution and the image is sent across an unsecured public network (7). Regardless of the mode transfer images and clinical data, various studies have concluded the benefits of image transfer in reducing the transfer rate, the range is between 20% to 40% (1,8-10). Telemedicine has saved a total of 400 000 km of ambulance travelling distance in Croatia over the span of 3 years (11). It is imperative for severe head-injured patient to be managed in the Neurosurgical unit as management in the peripheral hospital is associated with a higher risk of mortality. However, the main drawback of the system is the outcome of Neurosurgical patients that are kept in peripheral hospitals are largely unknown, and this made even worst with the lack of follow-up for these patients. The patients that have lack of follow-up and not admitted to Neurosurgery is the limitation on a quality assessment of the system (12). Patel et al demonstrated in his study that patients with severe head injury treated only in non-neurosurgical centers are associated with 26% increase in mortality and 2-15 fold increase in the odds of death compared with patients treated at a Neurosurgical centre. This data lend support to current guidelines, suggesting that treatment in a Neurosurgical centre represents an important strategy in the management of severe head injury (13). For patients with mild to moderate traumatic head injury and positive CT scan, neurosurgical intervention is not required, a study done by Fabbri et al, showed that observation in peripheral hospitals with neurosurgical consult by teleradiology system, repeat CT scanning and transfer time 30-60 minutes to a neurosurgical unit is not detrimental for subjects with initial non-neurosurgical lesions after mild-moderate head injury (14). Therefore, identification of a subset of patients with mild traumatic head injury that likely to deteriorate is important because these patients will need to be transferred even though they are in mild head injury group category. Carlson et al. identified a small percentage of mild traumatic head injury patients that have delayed deterioration requiring surgery with extra-dural haemorrhage (EDH) and sub-dural haemorrhage (SDH) being more concerning lesions. They concluded that in most cases of mild traumatic brain injury, a triage can be performed by a neurosurgeon and the patients can be observed without inter-hospital transfer (15). A prospective study by Zulu et al. on the outcome of patients managed conservatively in general surgical unit showed that it is an acceptable practice with outcome is determined primarily by the GCS on presentation. Patients managed in neurosurgical unit had significantly higher mortality rate (16). In this article, the focus is mainly on the impact of TeleNeurosurgery in reducing the number of unnecessary transfer. The phrase unnecessary transfer is the act of transporting a patient from one facility to another when the transport is not really required and where the transfer might cause further harm to the patient as well as the health system itself. Another aspect of unnecessary transfer is the act of keeping a patient in the secondary of primary level hospitals when the clinicians mistakenly think that the patient does not require transfer

to the tertiary level. In this setting, the patient might be at risk of deterioration from the disease itself due to the lack of experience in managing such cases that normally require an inter-facility transfer. The resultof this dissertation is in parallel with other studies done previously (1,5, 8–10,12, 17,18). We have found that by using this TeleNeurosurgery system, 37.1% of patients that initially thought need to be transferred are not transferred after imaging and clinical data being reviewed in TeleNeurosurgery system. With regards to the image quality sent through the teleradiology system.

Eljamel et al. found no significant difference in the quality of image between original CT scan films and the corresponding transmitted images, diagnosis and clinical decision (8). Goh et al. found unnecessary transfer was reduced by 21%. Significant difference in the amount of therapeutics measures before transfer were implemented (27% versus 20% without teleradiology) and significant reduction in the amount of adverse events (8 percent versus 32 percent without teleradiology). They recommended further attention for this system due to its potential advantage in facilitating safer transfers and faster management (9). In 2000, a study done by Eguare et al. concluded that a CT scan and image link facility permit remote neurosurgical advice and allow the majority of patients with a head injury to be safely managed in well-equipped regional units without onsite neurosurgical expertise (17). In 2002, Servadei etal provided a preliminary report on the integration of image transmission into a protocol for headinjury management. With the image link system, the neurosurgeons can evaluate the images of a number of patients who have always been treated outside neurosurgical unit and subsequently able to serve a better quality of service for the whole area (12). In 2004, Stormo et al found that image transfer was considered beneficial for the patient in 93% of cases and unnecessarytransfer reduced by 34%. Their results confirmed that teleconsultation between referringhospitals and a regional neurosurgical service influence patient management and reduce the frequency of patient transfer. This study found that mild head injury patients were likely to betransferred after images and clinical data were reviewed. The possible reasons include, better identification of patients with potential to deteriorate, for example, extradural haemorrhage with mild head injury which carry good prognosis if treated early. Trauma group is likely to be kept in the level II hospitals when both clinical data and images were reviewed, the possible explanation is that, this group of patients is likely to harbor multisystem injuries with normal CT brain findings which is better managed in the level II hospitals (10). The finding of 191 referrals or 54.7% of patients that were not transferred and managed remotely by the neurosurgeons represents a huge saving in term of health management as well as for the relatives as they did not have to travel very far or to find a nearest accommodation to be near closer to their next of kin. They could also alternate their responsibility to other family members and can pursue their own job while still taking care of their loved ones. This would results in continuous productivity on the part of the care takers. Telehealth is now considered an alternative mechanism for reducing the escalating health cost especially in government settings. In this report, a total of 9521 km of ambulance travelling distance was saved over the 4 months study period. If converted in term of money spent for the journey, this is considered a significant cost saving. Few studies had highlighted this issue. In 1994, Bell et al evaluated the initial experience of using the ImLink system for electronic CT image transfer in term of cost saving, they estimated a total saving of £5197.00, with each emergency transport cost estimated around £247.00 (19). The use of TeleNeurosurgery enhances the delivery of the consultation as the images and clinical data can be visualized anywhere at their own convenience. A local study by Narenthiranathan and colleagues in 2010 supports the findings of this study. They found that more than 50 percent of referrals were done outside office hours and their multimodality system to review referrals enables their input in decision making of patients care and improving the quality of services provided (5). The dedicated system located within the neurosurgical department means the system is accessible any time of the day (5).

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Authors' Contributions

Conception and design: JAS, NAAR
Drafting of the article, final approval of the article, provision of study materials or patient, statistical expertise and collection and assembly of data: RH
Critical revision of the article for the important intellectual content: JAS, NAAR, RH

Correspondence

Dr Risdhawati Hasan
MBBCh BAO (National University of Ireland).
MSurg Neurosurgery (Universiti Sains Malaysia)
Department of Neurosurgery,
Hospital Sultanah Aminah Johor Bahru
80100 Johor Bahru
Malaysia
Tel: +6019 714 4153
Fax: +607 2247 913
Email: rysinn1985@gmail.com

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