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ULTRASOUND - GUIDED ACCESS DURING PERCUTANEOUS NEPHROLITHOTOMY ON PATIENTS IN LATERAL POSITION ASSESSMENT OF OUTCOME IN 250 CASES TRAITED AT THE VIET-GERMANY FRIENDSHIP HOSPITAL, VIETNAM

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ABSTRACT

This study consisted of 250 patients including 176 (70.4%) males and 74 (29.6%) females with a mean age of 47.13 ± 24.31 years (range: 22-85 years). The renal stones were located at different sites. Pelvic stones accounted for 54.4% of cases, lower caliceal stones 7.6%, combined pelvic and one caliceal stone 35.6%; staghorn stones 22.4%; renal stones of the right kidney were found in 38.8% of cases, stones of the left kidney in 61.2%, and bilateral renal stones were found in 69 (27.6%) patients. Pre-operative hydronephrosis cases detected by Multi-Slice Computer Tomography (MSCT) were recorded as follows: Stone size: stone mean length: 2.41 ± 0.86 cm (1 – 4.8cm), stone mean width 1.62 ± 0.56cm (1-3.2cm). Access to the middle calyx was performed in 82.4% of cases, to the lower calices 16.8% and to the upper calices 0.8%. Mean operative time was 69.53±27.18 min (35-120 min). Intra-operative complications included 9 cases (3.6%) of haemorrhage not requiring blood transfusion. Post-operative complications occurred in 5.2% of cases, including 1 case of haemorrhage that was managed by selected embolization, 8 cases of fever, 3 cases of septic shock that was stabilized after a period of intensive care. The mean length of hospital stay was 4.57 ± 2.64 days (2-8 days). Nephrostomy tube was removed 2 -5 days after the operation (mean: 2.87 ± 1.43 days). Early post-operative stone-free rate was 80.7%. Follow-up examination and Double J stent removal was performed on 249 post-operative patients 01 month after the surgery with a stone-free rate of 96.8%. **Conclusion:** Ultrasound-guided Mini-Percutaneous Nephrolithotipsy performed on patients under spinal anaesthesia and placed in lateral position is a method that is highly beneficial for the patients, produces high stone-free rates (SFR) and less complications, and is quite easily applicable. It is highly recommended that Mini-PCNL be used in the treatment of kidney stones.

KEYWORDS

Renal stone, Mini-Percutaneous Nephrolithotripsy, Ultrasound – Guided and Patients in lateral position.

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INTRODUCTION

Percutaneous Nephrolithotripsy is currently the most popular minimally invasive method of treating renal stones. The use of PCNL has steadily increased as a replacement for the traditional open surgery besides other methods such as Retrograde Intrarenal Surgery (RIRS) and Extracorporeal

Shock Wave Lithotripsy. In recent years, significant improvements have been made to the PCNL method in terms of identifying stone location, puncture of the renal pelvis and calices, miniaturization of the access tracts, and enhancing instruments for the endoscopic grinding of stones, making it a highly efficient and much safer way of treating renal stones. From 2008, mini-PCNL has been performed worldwide with a smaller access tract to the kidney that measured only 12-20Fr, resulting in higher stone-free rates (SFR) and less complications than the standard PCNL which uses larger tracts of 12-30 Fr[1-4].

The standard PCNL was first performed in Vietnam in 2004 and has since been carried out in a large number of hospitals. However, the standard fluoroscopy-guided PCNL has numerous limitations and disadvantages. Mini-PCNL, on the other hand, has only been introduced in a small number of Vietnamese hospitals since 2012. Similar to the rest of the world, Mini-PCNL in Vietnam is performed in most cases on patients in the prone position and under endotracheal anaesthesia. In this study we will assess the effectiveness of kidney stone treatment using the Ultrasound-guided Mini-PCNL and 80w Holmium laser energy for stone fragmentation on patients under spinal anaesthesia and in lateral position.

PATIENTS AND METHODS

Patients

Over a period from March 2017 to August 2017, 250 patients with kidney stones have been treated by using Mini-PCNL procedures in the Surgical Urology Department of Vietnam-German Friendship Hospital, Hanoi.

The indications for percutaneous nephrolithotripsy included: (1) Solitary stones of the renal pelvis (S1-S2), partial or complete staghorn stones (S3-S4-S5) according to the classification of Moores WK and Boyce PJ (1967); (2) Caliceal stones or calyx diverticular stones; combined pelvic and ureteral stones or stones of the upper ureter that had been treated by a failed prior retrograde lithotripsy; kidney stones that had been treated by a failed prior Extracorporeal Shock Wave Lithotripsy (ESWL); and recurrent stones of prior interventions.

Methods

This is a prospective, descriptive study with longitudinal follow-up: (1) Pre-operative investigations**:** Pre-operative testing included: overall blood test, urine analysis, and imaging tests related to the morphology and function of the two kidney; these imaging tests also helped to assess the anatomic correlation between the urine collecting system and the morphology and location of the stones; coexistent renal pathology and urinary infection were also detected; (2) Preparation of surgical instruments: Endourologic instruments used for the surgery included: black and white abdominal ultrasound machine; 80w Holmium Laser device; lithotriptor with 550 µm tip; (3) Steps of the procedure: The patient received spinal anaesthesia:

Step 1

Initially the patient was placed in the supine position where a cystoscopy was performed to evaluate the bladder's inner surface while a catheter was inserted into the ureter and pushed to the renal pelvis.

Step 2

The patient was then turned 80º-90º into the lateral position, lying on his/her unaffected side and exposing the flank through which the renal access was made. A cushion was placed under the flank of the patient's unaffected side. Ultrasound was used to identify the location and morphology of the renal pelvis and stones, and to detect the most appropriate calyx for renal puncture, making sure that the skin-to-calyx distance is the shortest, and that access from the target calyx to other calices is possible.

Step 3

Incision of 0.7 cm in length was made in the lateral lumbar region, at the site of puncture determined by ultrasound. Caliceal puncture was then carried out with a 18G needle under ultrasound guidance.

Step 4

A curved-end guide wire was introduced into the urine collecting system. The access tract was then dilated using the plastic 6-18Fr dilators. 18Fr

Amplatz sheath was percutaneously introduced into the renal pelvis. A nephroscope was used to determine the location, number, and size of the stones in relation to the renal pelvic and caliceal anatomy.

Step 5

Stone fragmentation was performed by holmium laser small fibers at a 80w power setting. Irrigation was carried out simultaneously at 20-32 Kpa pressure level. Stone fragments were removed by irrigation or by retrieval pincers. After checking for stone clearance the ureteral catheter was withdrawn and replaced by an antegrade or retrograde insertion of a Double J stent. Through the access tract a 14Fr Foley tube was then placed antegrade in the renal pelvis for urine drainage. In some patients renal drainage was not necessary.

Post-operative follow-up: Post-operative follow-up included the following: (1) Monitoring and assessment of the patient's abdomen and general state of health, the assessment of the volume and colour of urine collected through the nephrostomy tube and the urethral catheter. Hemorrhage and urinary infection after the surgery should be identified in a timely manner; (2) Plain radiography was carried out 02 days after the surgery to confirm stone clearance (stone clearance was defined as no residual stone or residual stone fragments of less than 4mm in size). Renal drainage and urethral catheter were removed 2-4 days after the surgery, and the patient was discharged. A follow-up appointment is given for one month after discharge to receive a repeat X-ray for stone free rate (SFR) identification, and to remove the Double J stent.

RESULTS

This study consisted of 250 patients including 176 males (70.4%) and 74 females (29.6%), with a mean age of 47.13 ± 24.31 years (range: 22 – 85 years). The 41-60 age group, which consisted of 185 patients, made up the majority (74%) of the sample. 16 (6.4%) patients had unsuccessful previous Extracoporeal Shock Wave Lithotripsy (ESWL) treatment, with residual stone fragments detected in the kidney pelvis. 41 (16.4%) patients had undergone a prior open surgery to remove their renal and ureteral stones. 6 (2.4%) patients had undergone a previous laparoscopic retro-peritoneal surgery to treat ureteral stones on the same side. 8 (3,2%) patients had lost a contra lateral kidney after a previous nephrectomy or due to renal demise. 5 (2%) patients had undergone a previous Mini-PCNL on the contra lateral kidney. 18 (7.2%) patients were administered a second Mini-PCNL to treat large, complex and multiple kidney stones. 63 out of 250 (25.2%) patients had coexistent medical conditions including cardio-vascular and hypertensive diseases (23 patients), coronary artery disease requiring anti-coagulation therapy (7 patients), chronic cardio-pulmonary disease (3 patients), diabetes mellitus (5 patients), first-and-second-degree renal failure (22 patients), and spinal kyphosis (3 patients). 11 (4.4%) patients with a medical condition of the urinary system were given non-surgical treatment and Double J stent placement prior to undergoing the mini-PCNL procedure.

Stones sizes were recorded as follows: Mean length: 2.91 ± 0,86 cm (1 – 4.8 cm); mean width: 1.82 ± 0.56 cm (1 – 3.2 cm); and mean surface: 3.17cm^2. Location and morphology of the kidney stones as shown in Table No.1. Caliceal puncture target as shown in Table No.2.

Intra-operative bleeding complications occurred in 9 (3.6%) patients during the manipulation for access to the S2-S5 stones. In these patients the renal pelvis and calices were not dilated but surrounded by a thick renal parenchyma; no coagulation disorder was detected and blood transfusion was not needed.

The Mini-PCNL procedure was successful in all patients. Mean operative time was 69.53 ± 27.18 min (35 - 120 min). The longest operative time was noted in the cases of S5 stone, while the shortest one was recorded in the cases of S1, S2 and of caliceal solitary stones. The antegrade placement of Double J6 or 7Fr stent was favorable in 234/250 (93.6%) patients. In 5 (4.4%) patients these stents were introduced retrograde due to the angulation between the access tract and the uretero-pelvic axe. 12.14 Fr Foley tube was placed for renal drainage in

247 (98.8%) patients. Three (1.2%) patients dose not received tubeless drainage.

Post-operative complications occurred in 13 (5.2%) patients and included: one case of haemorrhage that was managed by artery embolization, 8 cases of fever, 3 cases of septic shock that were managed in intensive care until stabilization.

Post-operative transfusion was given to 3 patients, who received 2 units of blood each. These patients included 1 post-operative haemorrhage and 2 with prolonged PCNL due to S5 larger stones.

Early radiography was performed within the first three postoperative days to identify residual stones. In 48/249 (19.3%) patients, stones of ≥ 4mm in size were detected. Early stone-free rate (SFR) was 80.7%. In 18 out of the 48 patients with residual stones, the nephrostomy tube remained in place and the residual stones were treated by a second PCNL 1-2 weeks later.

Nephrostomy tube was removed after 2 - 5 days (mean: 2.87 ± 1.43 days). Mean length of hospital stay was: 4.57 ± 2.64 days (2 - 8 days). In later follow-up appointments 1 month after the operation, 249 patients were re-examined and did not show any symptoms of pain and fever. X-ray imaging showed a 96.8% stone-free rate for this group, with 242 out of 250 patients retaining no residual fragments or stones ≥ 4mm in size. Stone-free patients had their double-J stent removed, while Extacorporeal Shock Wave Lithotripsy (ESWL) was performed for seven (2.8%) patients with residual stones. No open surgery or other intervention was needed. No complication such as hematuria, severe urinary infection, or ureteral obstruction caused stone was observed.

DISCUSSION

In parallel with the development of technology, kidney stones treatment has significantly evolved from open surgery to minimally invasive surgical procedures. Standard PCNL with a 24-30Fr tract size has been widely recognized as one of the most powerful instruments as it allows for rapid stone removal and is highly efficient in treating large kidney stones and complex staghorn stones. However, standard PCNL is also associated with a higher risk of haemorrhage and damage to the renal parenchyma.

Mini-PCNL, which uses smaller access tract (≤18Fr), has produced very promising initial results with reduced risk of bleeding and less trauma to the renal parenchyma. The use of high power 80w Homium laser enables a faster destruction of stones, and enhances stone fragmentation. Stone fragments can be easily removed during the lithotripsy procedure, resulting in a higher efficiency rate of stone clearance. In the treatment of complex staghorn stones where multiple accesses are needed, the use of smaller tracts has demonstrated Mini-PCNL's superiority over other methods. Some studies have also reported that Mini-PCNL was as efficient as the standard PCNL in the treatment of larger kidney stones[3,4].

In this study the use of Mini-PCNL in treating complex staghorn stones accounted for 23.2% of cases, of which 12.4% were S4 stones and 10.8% were S5 stones. In the majority of cases with S4-S5 stones, the renal pelvic and caliceal system either was not dilated or was only dilated at degree 1. On the other hand, degree 2 and 3 dilation of the system was observed in S1 and S2 stones. In reality, the degree of dilatation of the renal pelvic and caliceal system was proved to have a direct impact on the success of renal puncture. In our study, 231 patients (92.4%) received one-session Mini-PCNL, 18 patients (7.2%) received a repeat procedure and only one patient (0.4%) underwent a third surgery because of large complex staghorn stones occupying multiple calices.

In eight patients (3.2%) with a single kidney, Mini-PCNL was performed with the purpose of avoiding open surgery, regardless of whether the stone to be removed was solitary or complex. Mini-PCNL was also proved to be very useful for the management of recurrent kidney stones in patients with a history of previous surgery in the costo-lumbar region, mainly because in this procedure the renal puncture and access tract establishment cannot be hindered by the retro-peritoneal fibrous adherences left by a previous surgery. In this study, 47 patients (18.8%)

received Mini-PCNL to remove recurrent kidney stones that had undergone a previous surgery for treating renal stones of the same side.

Ultrasound guidance was first developed by Peterson in 1976. In recent years Ultrasound-guided access during percutaneous nephrolithotomy has been widely reported as an approach with high success rate. Gamal[5] reported a series of 34 PCNL in which only ultrasound guidance was used during the whole procedure with a stone-free rate 94%. Samad Zare (2017) reported a study of 250 patients that underwent kidney stones treatment by ultrasound guided-PCNL over a period of 5 years, from 2012 to 2016. Large access tracts were used on patients under lateral position. Primary stone-free rate at the time of hospital discharge was 68%[12].

In this study, stone localization and identification of puncture site was carried out completely under ultrasound guidance. Despite the many advantages of this method, research on ultrasound localization of kidney stones has been relatively limited in Vietnam. In fact, ultrasound guidance was proved to be highly accurate, and helps detect non-opaque stones that cannot be seen by fluoroscopy. Moreover, ultrasound guidance also allows for the assessment of the stones in relation to the kidney and other intra-abdominal organs. Visualization of the needle tip during the puncture helps to accurately determine the depth and direction of the dilators, making the procedure safe and resulting in high success rate. Other advantages of ultrasound guidance over fluoroscopic guidance include radiation avoidance, and shorter operative time. Ultrasound can be used both intra-operatively and post-operatively to verify stone clearance, which significantly reduces operative times[6].

The classic prone position for PCNL was first performed in 1976 by Fernstrom and Johansson. Yet this position is believed to negatively affect anaesthesia and rehabilitation processes, especially in high-risk patients with cardio-pulmonary disorders or obesity. In 1987 Valdivia Uria *et al.*[7] presented the supine PCNL. Their report published in 1998 suggested that supine position allowed for simultaneous use of antegrade and retrograde renal accesses during PCNL, and reduced risks of anaesthesia-related complications.

Data of the Clinical Research Office of Endourological Society (CROES) on PCNL performed in 96 global participating centres from 2007 to 2009 showed that prone position remained the most used position in PCNL treatments, accounting for 80.3% of the sample. For patients with risks of respiratory compromise and/or anomalies of the spinal columna, the lateral position associated with spinal anaesthesia is highly recommended. In this study these two morbid conditions were encountered in 6 patients (3 with respiratory compromise and 3 with kyphosis).

In this study, PCNL was performed on patients in the lateral position and under spinal anesthesia for a number of reasons. Firstly, the lateral position might reduce the risk of respiratory and circulatory compromises, and allows the surgeon to monitor the patient, who is kept awake during the surgery. This enables the early detection of intra-operative complications such as organ injury or retro-peritoneal extravasation[11]. Secondly, turning the patient from supine to lateral position will be easier when repositioning is needed. Thirdly, we intend to avoid prolonged operative times in order to reduce the risk of hemorrhage and especially the risk of sepsis caused by bacterial invasion into the circulatory system.

In this study the maximum operative time was 90 min. For larger stones, operative time was not prolonged. Instead, the stones were treated by multiple PCNL procedures. All Staghorn stones of different levels of complexity were treated by Mini-PCNL. However, PCNL performed under spinal anaesthesia in the lateral position also has several drawbacks. Firstly, patients kept awake during the operation might be agitated and anxious. Secondly the kidney is more mobile in this position, making caliceal puncture and renal access more challenging.

Caliceal puncture and tract establishment for renal access are the most critical steps of PCNL, with a direct impact on the success and complications rate of the procedure. The selection of renal access must be based on the results of preoperative imaging tests and intra-operative ultrasound. In our study one access tract was established in 237/250 (94.8%) patients, and two access tracts were needed in 13 patients (5.2%).

The middle calyx was the most common renal puncture site, accounting for 82.4% of cases (206 patients). In fact, the pelvis and its dependent middle calix offer the largest area for renal puncture, and from this site of Amplatz placement access to the other calices might be more favourable and easier. Similarly, access to the ureter to assess its patency and to place the Double J stent was also easier.

Puncture of the lower calix was performed in 42 patients (16.8%). These were mainly patients with lower caliceal stones or a combination of pelvic stones and lower caliceal stones. Upper calix puncture was the least common in this study, and was carried out in only 2 patients (0.8%). In both cases, two tracts were needed as the stones were either type S4 or S5, and the stone-bearing calyceal diverticula was totally inaccessible from the middle calyx. In fact, upper calyceal puncture is more challenging than other approaches because of costal hindrance and the risk of pleural injury. Upper caliceal lithotripsy was also more challenging.

In patients with a surgical scar in the costo-lumbar region, renal puncture became easier if the patients were placed in lateral position because the kidney was relatively fixed by fibrous adherences from the previous surgery. In this study, costo-lumbar surgical scars were observed in 41 patients. Intra-operative assessment of these patients showed that the peri-renal tissues and the renal parenchyma had become fibrous and harder due to the inflammatory process following the previous surgery. As a result, access tract dilation and caliceal puncture were more difficult.

For complete staghorn stones or larger complex stones occupying several calyces, the use of single-tract PCNL would result in prolonged stone fragmentation and lower stone free rate. Based on the characteristics of the stones, appropriate approaches such as one-session PCNL, repeat PCNL or a third PCNL could be selected, with the use of a maximum of 03 tracts. The purpose is to reduce operative time and increase stone-free rates. In our study, the majority (94.8%) of the 145 staghorn stone cases were treated by single-tract Mini-PCNL. Two access tracts were only needed in 13 cases (5.2%).

The duration of puncture, tract establishment and caliceal Amplatz placement depended on several factors such as the surgeon's experience, the location and size of the stone, and the degree of pelvic and caliceal dilatation. For stones that are confined to the renal pelvis, both renal puncture and stone fragmentation can be done fairly easily. In addition, the greater pelvic and caliceal dilatation, the easier it is to perform renal puncture and Amplatz placement. Dilatation degree II was considered to be the most favourable condition for renal puncture, pelvic Amplatz placement and stone fragmentation.

For large-sized stones, thick renal mesenchyma and the lack of proper pelvic and caliceal dilatation could make renal puncture and access tract establishment challenging. However, easy renal puncture and stress-free tract establishment do not necessarily lead to easy stone fragmentation. Indeed, hydronephrosis degree III was often associated with difficult stone fragmentation because the stone is relatively mobile, causing prolonged operative time, increased residual stone rate, and the need to keep the nephrostomy tube for a longer period of time.

Intra-operative haemorrhage was the most serious complication of PCNL, and occurred mainly during renal puncture and access tract dilation. These manipulations might cause injuries to the renal parenchyma through which the renal puncture and access tract were carried out. Successful renal puncture and Amplatz placement could allow for the whole operation to be well controlled, and as a result complications such as renal parenchyma and vessel injuries were not often encountered.

Intra-operative haemorrhages occurred in 9 patients (3.6%) of our study. These cases were characterized by thick renal parenchyma, the target calyx being occupied by S2-S5 stones and the pelvic and caliceal system was not dilated. The bleeding was managed by advancing the Amplatz sheath to create a compression effect over the renal parenchyma. No coagulation disorder was observed and blood transfusion was not needed in any patient.

At the conclusion of the PCNL procedure, the placement of ureteral Double J6 or 7Fr stent has been highly recommended to ensure the safety of the procedure. The placement of antegrade Double J stent was carried out satisfactorily in 234 (93.6%) out of our 250 patients. Retrograde placement was needed in 11 patients due to the angulation between the lower calyx and the uretero-pelvic axe.

Though it might result in pain, discomfort and prolonged hospital stay, nephrostomy tube placement at the end of the surgical procedure has been considered standard approach in PCNL. Besides the main purpose of tamponading bleeding from the tract, nephrostomy tube could also be used to provide urinary drainage in case of hydronephrosis and/or ureteral obstruction, or when ureteral stent placement is impossible, and to monitor patients with high risk of intra- or post-operative haemorrhage.

In the beginning of our study, the placement of antegrade double-J stent and a 12-15Fr Foley tube was carried out in all patients. The Foley tube was removed 2-5 days later, after being temporarily griped and if the patient was fever-free. In fact, only a small quantity of urine outflow through the Foley tubes was recorded in our patients. If the patient was at lower risk of haemorrhage, and the Mini-PCNL procedure was performed within short operative time, the Foley tube could be removed earlier. No urine leakage or retroperitoneal fluid accumulation was observed in any of our patients after removal of the Foley tube. Some authors have also suggested that nephrostomy tube placement could be left after PCNL to allow for access for an early second-look procedure if residual stones were detected after the first surgery.

Post-operative complications occurred in 13 patients (5.2%) of our series and included: 1 case of haemorrhage that was managed by selected embolization, 8 cases of fever, and 3 cases with septic shock symptoms that were managed by antibiotic therapy and by intensive rehabilitation until the patients were stabilized.

Post-operative transfusion were given to 3 patients, who received 2 units of blood each. These patients include one case of post-operative haemorrhage mentioned above, and two cases of prolonged PCNL due to large and complex S5 stone combined with intra-operative haemorrhage and a hidden anemia detected post-operatively.

Early radiography within the first three postoperative days showed residual stones ≥4mm in 48/249 patients (19.3%), meaning that the primary post-operative stone free rate was 80.7%. In 18 out of these 48 patients the nephrostomy tube remained in place and a second PCNL was performed 1-2 weeks later, producing good results.

In the late follow-up period 250 patients were re-examined 01 month after the operation, and showed no sign of fever and/or pain. X-ray imaging showed that 242 out of these 250 patients (96, 8%) were stone free, thus had their Double J stent removed. Residual stones were detected in 8 patients (3.2%) who were then managed by Extracorporeal Shock Wave Lithotripsy (ESWL). No open surgery or other intervention was needed. No other complications such as hematuria, severe urinary infection, or ureteral obstruction were observed.

Stone free rates (SFR) as reported by the literature range from 62% to 94.3%. This large variation may be caused by inconsistencies in the selection criteria of stones for PCNL treatment, and by the different methods and energy sources used in nephrolithotripsy. In our study the stone free rate after the first Mini-PCNL procedure was 80.7%. The percentage of residual stones (19.3%) was associated with multiple S4-S5 complex staghorn stones which occupied different calices, and are very difficult to access.

Table No.1: Location and morphology of the kidney stones

S.No	Location and Morphology	Number of Patients	Percentage (%)
1	S1	27	10,8
2	S2	59	23,6
3	S3	89	35,6
4	S4	31	12,4
5	S5	25	10
6	Lower caliceal stones	19	7,6
Total		250	100,0

Table No.2: Caliceal puncture target

S.No	Caliceal target	Location and morphology of the kidney stones						Number of cases (%)
		S1	S2	S3	S4	S5	Lower caliceal stones	
1	Upper calyx		0	0	1	1	0	2 (0.8%)
2	Middle calyx	25	51	80	23	19	8	206 (82.4%)
3	Lower calyx	2	8	9	7	5	11	42 (12.6%)
Total		27	59	89	31	25	19	250 (100%)

CONCLUSION

Percutaneous nephrolithotripsy through a 18Fr small tract under ultrasound guidance using high power laser energy, with the patient placed in the lateral position and under spinal anaesthesia was proved to be a safe and effective method for treating kidney stones which results in high stone-free rates (SFR) and low rates of post-operative complications. It is recommended that this method be used more widely in Vietnamese hospitals.

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CONFLICT OF INTEREST

We declare that we have no conflict of interest.

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