Evaluation of the Diagnostic Accuracy of Intra-Abdominal Pressure Measurement Method Through Bladder in Predicting Renal Dysfunction After Kidney Transplantation

nahid aghebati (✉ aghebatin@mums.ac.ir)

Mashhad University of Medical Sciences

mahtab torkamani

Mashhad University of Medical Sciences

hamid heydarianmiri

Mashhad University of Medical Sciences

mahmoud tavakkoli

Mashhad University of Medical Sciences

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Abstract

Background

The patients undergoing kidney transplantation are at risk of increasing Intra-Abdominal Pressure (IAP) due to the abdominal surgery.

Methods

This diagnostic accuracy study was conducted on 135 patients, who had undergone kidney transplantation from alive and brain death patients in two hospitals of Iran and Afghanistan, in 2019. The patients' intra-abdominal pressure was measured every 6 hours up to 24 hours after surgery by nurses. The indices of renal dysfunction were utilized, including creatinine level, urine volume, need dialysis and thymoglobulin after transplantation and nephrectomy in 6 months. The sensitivity as well as positive and negative predictive value of the IAP test was counted based on these indices. Doppler ultrasound of the transplanted kidney was used as a gold standard diagnostic test. Data analysis was done by using STATA 14.

Results

According to the results 10 (7.4%) people of 135 patients were observed with IAP > 10mmhg. Nobody revealed IAP > 15. Seven (5.2%) patients had Urinary loss and 20(15%) didn't show creatinine decrease more than 25% of baseline. Twelve (9 %) of them need dialysis and thymoglobulin, and had positive Doppler ultrasound. Finally 3 (2.2%) patients were undergone nephrectomy during 6 months. All of these indices indicated a significant ($p < 0.05$) correlation with IAP mean difference (4 – 1). A comparison between the diagnostic power of IAP measurement method and Doppler ultrasound indicated 90% of sensitivity and 94% of negative predictive value in predicting the renal dysfunction.

Conclusion

Results of the present study revealed that the IAP measurement through bladder catheter can be used by the ICU nurses before Doppler ultrasound in kidney transplantation but we need more data to recommend this test.

Introduction

Kidney transplantation is the only ultimate treatment for patients with kidney failure and has the highest survival benefits among other alternative therapies for kidney failure; It also leads to improvement of many complications of chronic kidney failure, enhancement of life quality, and prolongation of the individual lifetime (1). Despite the fact that kidney transplantation is an appropriate selective treatment in

patients with renal failure, the emergence of internal and subsequent surgical complications could exacerbate high-risk conditions, such as transplant rejection, and Delayed Graft Function, and even the patient death (1, 2).

The one who nurses the transplant patient plays a substantial role in diagnosis of acute transplant complications that often occur within the first 24 hours after transplantation. The nurse is able to diagnose complications such as renal dysfunction, appearing in the form of decreased urinary output and increased serum creatinine, both with the aid of the obtained knowledge and through urgent intervention (3, 4). Increase of IAP is one of the complications of major abdominal surgery, to which kidney transplant patients are exposed to due to the nature of surgery and its method. Higher IAP reduces blood supply to the transplanted kidney and eventually leads to its ischemia; this phenomenon is defined as kidney transplantation compartment syndrome and might be undetectable. This syndrome is further likely to be confused with many transplant complications such as vascular thrombosis and other surgical causes (5, 6). According to Abdominal Compartment Syndrome Association, IAP measurement is recommended for all the patients, who are in Intensive Care Unit with clinical conditions, predisposing them to higher IAP in order to prevent Abdominal Compartment Syndrome. Among these clinical conditions abdominal surgery, fluid accumulation in the peritoneum, acidosis, could be mentioned (7). IAP measurement through Bladder (*Crohn's Method*) was introduced by the Abdominal Compartment Syndrome Association in 2006 as the simplest, the most cost-effective, and the most reliable method to measure IAP (7, 8).

Therefore, if we predict the probability of renal dysfunction which could emerge due to transplantation, followed by increase of IAP and transplanted kidney compartment syndrome, not only could we prevent the syndrome but also we could reduce the probability of transplantation rejection. Update, there is no previous study conducted on the prediction of renal dysfunction in patients with transplanted kidney, by means of IAP measurement through bladder. Doppler Abdominal ultrasound of transplanted kidney is the most common diagnostic test to use for these patients; not only is this test expensive, but it is not always available. Given that nurses are the permanent caregivers of patients, it would be ideal to use a simpler and more economical diagnostic method, which can both be performed by nurses and predict renal failure in patients with transplanted kidney.

Hence, the present study aimed to evaluate the diagnostic accuracy of IAP measurement method via bladder catheter in predicting the probability of renal dysfunction after transplantation.

Method

In this single-group longitudinal study that was confirmed in the Ethics Committee of Mashhad University of Medical Sciences, Mashhad Iran. (IR.MUMS.NURSE.REC.1397.081) and adhered to the STARD guidelines for diagnostic accuracy studies, Patients, who were admitted to two kidney transplant centers of Iran and Afghanistan., and were undergone kidney transplantation, from February 2019 to the end of October 2019, participated in the study as the sample group after obtaining written informed consent.

The sample size was considered to be 135 with the help of STATA 14 statistical software and according to papers (9).

Patients who received kidney transplantation entered the study in coordination with the related physician, based on inclusion criteria, including age range of 13-65 years, willingness to participate in the study, not being afflicted by urinary tract or neurogenic bladder disorders, and not undergone bladder transplantation. They were excluded from the study under some circumstances, such as refusal to continue participating in the study, death. The patients would be also excluded if the researcher was not able to control IAP because of conditions, including the patient's intolerance of testing, incidence of respiratory distress, hemodynamic changes, non-authorization by the physician, and suprapubic catheter placement.

Among the transplanted patients at the research period, two patients due to *neurogenic bladder*, and one patient due to *urethral stricture* and *suprapubic catheter* insertion were excluded. Finally, 135 patients were included in the study and their data were analyzed (figure1).

IAP measurement through bladder was made every 6 hours after transplantation for 24 hours. Afterwards, it was done 48 and 72 hours after transplantation if IAP was higher than and equal to 12.

Data collection instruments

For each patient, a form containing information related to the patient's demography, diseases, 24-hour urine volume, type of dialysis (hemodialysis or peritoneal), and history of the previous transplantation were recorded. Each patient's postoperative information were recorded and examined in a checklist including: vital signs (pulse, blood pressure), the rate of intake and output within the first 24, IAP scores every 6 hour up to 24 hours, laboratory parameters (urea, and creatinine) during 24h, 72h and a week after surgery. The need for dialysis and Thymoglobulin, and also the results of renal artery Doppler ultrasound were also checked.

Procedure:

In the present study, IAP measurement through the bladder catheter was utilized considering the constraints in two countries , and the existence of simple urinary catheters, not equipped with culture aspiration port from each patient's urinary tube –as a route of water elevation along the scale of centimeter of water .

Here, the capillary effect (i.e., the tendency of liquid to rise in low-diameter tubes) was used. This study was initiated by putting the patient in a supine position, so that the abdominal muscles were in a relaxed state. It was proceeded by entering 50 cc normal saline slowly into bladder through the path connected to urine bag, and the path was then clamped. At this time, the urinary bag tube was emptied. After that, the scale zero point was placed at the joining point of iliac spine and armpit midline, and at the same level or Pubic symphysis of patient; the tube of urinary bag was also fixed from the junction to the catheter at zero point, and the rest of urinary tube was held at the zero level of the scale. After 30 to 50 seconds, the

patient was asked to hold his breath, and then the clamp was opened for urine to move along the path of the urinary bag tube and rise through the scale level; the number indicated IAP at the point, where urine stopped and fluctuated with the patient's breath (figure2).

The most important point in IAP measurement is the zero point of the scale or *transducer* that should be placed in the mid axillary and iliac lines, and parallel to the *pubic symphysis*. An appropriate volume of bladder as well as a minimum time of 30 seconds are necessary to relax the bladder muscles. Entering an excessive volume of fluid or allowing the bladder to relax too much result in a false high number for IAP. Body position can contribute to an accurate IAP number, so that bed height above 10 to 20 degrees can lead to a false high number for IAP. (10,7)

According to Abdominal Compartment Syndrome Association, there are three grades for IAP : grade (1) IAP range of 12-15 mmHg, grade (2) IAP range of 16-20 mmHg, and grade (3) IAP range of 21-25 mm Hg. (7).

The indices used to predict renal dysfunction included the urinary output less than 100 cc/hr, lack of creatinine depletion of less than 25% of baseline, Delayed Graft Function (dialysis requirement in the first week of transplantation), and Doppler sonographic changes (increase in vascular resistance).

Data analysis

The statistical analysis was performed after collecting and encoding data by using STATA software version 14. Descriptive statistics, including the distribution of relative frequency, mean and standard deviation were used to describe the characteristics of research sample. To decide on an appropriate test for examining the correlation between variables, the compatibility of variables distribution with normal distribution was examined by means of the Shapiro-Wilk test. Since the distribution of quantitative variables did not follow normal distribution, the Mann-Whitney test was employed and the significance level was considered to be 5% in all tests.

The statistical tests were used in a way that, first, the correlation between IAP variables or their conversions with dichotomous variables, indicating renal dysfunction (i.e., decrease of urine volume lower than 100 cc/h, creatinine decrease less than 25% of preoperative baseline, and delayed function of the transplanted kidney) was examined by the Mann-Whitney test. Then, the predictive power of IAP variables for renal dysfunction was evaluated by using the System Performance a *Receiver Operating Characteristic* (ROC) curve; the sensitivity, specificity, as well as positive and negative predictive values were calculated by considering the area under the curve for each of their values (*cut-off point*). Next, a combination of tests with maximum sensitivity, specificity and predictive values was administered in series or sequential, and parallel forms by employing the Multiple Testing approach. The basis for comparing the *cut-off points* was the predictive or diagnostic power of *Youden's* and *d2* indices[1][2]; ultimately, a final *cut-off points* with the highest *Youden's* index and the lowest *d2* index was recorded. Finally, the sensitivity and specificity identified in the *Youden's* and *d2* indices were determined in IAP

differences of 1-4 and 1-3; multiple sequential and parallel testing methods were used and sensitivity and specificity were determined by combining these tests in a parallel-sequential multiple test (11, 12).

Given the low incidence of renal dysfunction among the patients under study, sensitivity, which indicated the ability of a test to detect cases of disease was proved to be more important in this study. On the other hand, the low incidence of renal dysfunction among the patients under study caused the negative predictive value of the test to be important since this index showed the ratio of healthy cases to all the cases with negative test reports. Therefore, determining the negative predictive value of the test was more emphasized in the study, and on this account a combination of parallel statistical test was used with the highest sensitivity and negative predictive value.

Footnotes:

[1] Youden's= (Sensitivity + specificity) -1

[2] $d2 = (1 - \text{sensitivity})^2 + (1 - \text{specificity})^2$

Results

Women and men comprised 31.9% and 68.1% of the patients under study, respectively (Table 1). The results showed hypertension 22.2% was the most prevalent chronic disease (Table 2).

Table 1
Frequency distribution of demographic information of patients undergoing kidney transplantation

Variable	Frequency		Percentage
Gender	Male	92	68.1%
	Female	43	31.9%
Dialysis	Blood	123	91%
	Peritoneal	12	9%
Kidney transplantation Iran	Live	12	9.9%
	Cadaver	81	60%
Kidney transplantation Afghanistan	Live	42	31.1%
	Cadaver	0	0
Total	-	135	

Table 2
Frequency distribution and percentage of information on disease records
in patients with kidney transplantation

Risk Factor	Frequency	Percentage	Total
High Blood pressure	Yes 30	22.2%	135
	No 105	77.8%	
Diabetes	Yes 4	3%	135
	No 131	97%	
Mental Illness	Yes 4	3%	135
	No 131	97%	
Substance abuse	Yes 3	2.2%	135
	No 132	97.8%	
Cardiovascular diseases	Yes 4	3%	135
	No 131	97%	
Taking medication for illness	Yes 23	18%	135
	No 112	83%	
Other diseases	Yes 24	17.8%	135
	No 111	82.2%	
Observed urine before the surgery	Yes 9	6.7%	92
	No 83	61.5%	
Total number	135	100%	-

Out of 135 patients, 7.4% (10 patients) experienced IAP increase higher than 10, and 31.6% (43 patients) had at least one IAP higher than 8 in four IAP measurements in a day. Renal dysfunction had a low prevalence with a 15% of incidence. Nobody revealed IAP > 15. The results showed that none of the patients experienced IAH (Intra-Abdominal Hypertension).

In the present study, prediction of renal dysfunction, means of IAP were compared with the aid of the Mann-Whitney test, based on creatinine depletion index less than 25% of preoperative baseline creatinine as a dichotomous variable, during a week after surgery. Test results indicated that patients with less than 25% of creatinine depletion from baseline in the first week after surgery had a significantly higher IAP mean difference than normal patients. There was also a significant correlation between IAP (1–4) difference and on creatinine depletion index ($P = 0.001$) ($z = -3.24$) (Table 3).

Table 3

Comparison of mean and standard deviation of intra-abdominal pressure in patients undergoing kidney transplantation with two-state indices of renal adequacy assessment

Variable	Number- Percentage	Mean(SD) IAP 1	Mean(SD) IAP 4	Mann-Whitney test P-value
Urine volume less than 100 cc/h	7 5.2%	3.64(3.09)	6.71(5.02)	Z =-3.27
Urine volume greater than 100 cc/h	129 94.8%	5.83(3.35)	4.27(2.66)	P-value = 0.001
Creatinine Reduction less than 25% of baseline in the first week after surgery	20 15%	4.52(2.32)	5.7(2.75)	Z =-3.24
Creatinine Reduction greater than 25% of baseline in the first week after surgery	113 84.9%	5.94(3.49)	4.19(2.83)	P-value =0.001
Need to Dialysis after transplantation	12 9%	3.7(3.15)	5.41(3.42)	Z=- 2.97
Not to need dialysis after transplantation	123 91%	5.92(3.33)	4.3(2.79)	P-value = 0.002
Patients with high vascular resistance in Doppler ultrasound	13 9.6%	4.96(3.46)	6.23(4.54)	Z =-2.19
Patients with normal vascular resistance in Doppler ultrasound	122 90.4%	5.8(3.35)	4.67(3.16)	P-value = 0.01

Using Multiple Testing approach and considering the low incidence of renal dysfunction in the present study, a *parallel test* was used to determine the sensitivity and negative predictive value. Accordingly, higher IAP correlated with lack of creatinine depletion index more than 25% of baseline could predict the renal dysfunction with 98% of sensitivity and 98% of negative predictive value of (Fig. 3).

Furthermore, IAP means were examined and then were compared by means of the Mann-Whitney Test based on urinary volume index of less than 100 cc/h as a dichotomous variable, within the first 24 hours after transplantation. The obtained results showed a significant correlation between IAP(1–4) difference and urinary reduction in predicting the renal insufficiency ($P = 0.001$) ($z = -3.27$). It suggested that Patients with lower urine experienced higher IAP mean than other patients (Table 3).

As a result, higher IAP correlated with urinary loss index could predict renal dysfunction with a sensitivity of 91% and a negative predictive value of 97% (Fig. 4).

In line with the renal dysfunction evaluation, *Delayed Graft Function* (DGF) rate was investigated as an indicator of renal insufficiency. According to sources, *Delayed Graft Function* is explained by the need for dialysis and thymoglobulin due to the renal insufficiency in the first week after transplantation. In this study, means of IAP were compared by using the Mann-Whitney Test, and based on dialysis and thymoglobulin requirement index as a dichotomous variable, within the first week after transplantation. The results revealed those patients in need of postoperative dialysis and thymoglobulin, had a higher mean of IAP; the dialysis and thymoglobulin requirement index was further significantly correlated with IAP (1–4) difference ($p = 0.002$). ($z = -2.97$) (Table 3).

In this regard, higher IAP correlated with dialysis index was able to predict renal dysfunction with 96% of sensitivity and a negative predictive value of 98%. (Fig. 5).

Moreover, the prediction of renal dysfunction and means of IAP were evaluated on the basis of *nephrectomy* incidence index as a dichotomous variable, and the means were then compared by the Mann-Whitney Test. The results indicated that patients, who had undergone postoperative nephrectomy significantly had a higher first mean of IAP than patients with no nephrectomy –related problem ($p = 0.05$). ($z = 1.97$) (Table 3). By applying Multiple Testing approach, the parallel test was utilized to determine sensitivity and negative predictive value. Therefore, higher IAP based on *nephrectomy* index could predict renal dysfunction with 94% of sensitivity and 99% of negative predictive value.

Besides, comparison between Doppler ultrasound and IAP after kidney transplantation was made as a dichotomous variable. The first group were those patients who experienced higher venous resistance in Doppler ultrasound of the transplanted kidney; the second group had normal Doppler ultrasound of the transplanted kidney. Both groups were compared by the Mann-Whitney Test and the results indicated that patients with higher venous resistance in Doppler ultrasound of the transplanted kidney had a significantly higher IAP mean; there was also a significant correlation between the Doppler ultrasound index and IAP (1–4) ($p = 0.01$) ($z = -2.19$) (Table 3).

IAP increase compared with Doppler ultrasound could predict renal dysfunction with 90% of sensitivity and a negative predictive value of 94% (Fig. 6).

Discussion

Given that the present study was aimed at determining the diagnostic accuracy of IAP measurement method through bladder catheter to predict renal dysfunction in patients, who had kidney transplantation, renal dysfunction relied on different specific indices. Thus, the discussion process would revolve around the main objective of determining the diagnostic value of IAP measurement through bladder catheter to predict the incidence of renal dysfunction.

Generally, findings of this study indicated that the rate of renal dysfunction was low (15%) among 135 patients, who had undergone kidney transplantation in two countries. Based on the findings, we utilized the sensitivity, which was indicative of a test ability to find cases with higher IAP and negative predictive value, which pointed to a test ability to identify healthy individuals with no renal dysfunction and normal IAP.

Along with this study, Murphy (2018) et al. (13) studied on 285 patients, admitted to intensive care and surgical intensive care units. There was a rate of IAP increase up to 30% at admission and a rate of 15% after admission; prevalence of Abdominal Compartment Syndrome was reported 3%. Malbrain et al (2005)(14) studied on 256 patients admitted to 14 surgical intensive care units in five countries and reported a rate of 65% for IAP increase and a rate of 5% for Abdominal Compartment Syndrome. According to a study by Tiwari et al (2016) (15) on 30 patients with *Penetrating Abdominal Trauma* (PAT), in IAP increase was reported to be 32% and Abdominal Compartment Syndrome was reported to be approximately 14–15% .

Hence, Based on a comparison made between the results of this study and studies by Malbrain et al., Murphy et al., and Tiwari et al., IAP increase had a rate of 9.5% in the present study that was less than the above studies.

It should be acknowledged that in the present study, patients were candidates for kidney transplantation, and their hemodynamic and abdominal complications status were under control according to surgical conditions. Patients with various abdominal and hemodynamic disorders were not candidates for transplantation, while patients, who were studied by Malbrain, Murphy, Tiwari et al., were admitted with different pathologies, such as sepsis, abdominal surgeries and traumas; internal patients were also hospitalized under mechanical ventilation with a risk factor of higher IAP and Compartment Syndrome. Therefore, their finding is expectable among the population. While, in the present study, the incidence of transplantation complications was low in the patients due to the progress of kidney transplantation operations and controlled nursing care.

acute IAP increase has adverse effects on the cardiovascular system, reduces the cardiac output and venous return and blood flow to the *mesenteric* vein, stimulates the *renin- angiotensin* system, and consequently, contraction of the arterioles and renal vein, reduction of renal blood flow, and increase of the hydrostatic pressure of the *Bowman's capsule* that, in turn, reduces the glomerular filtration rate and decreases the urine volume. According to various studies, an inverse correlation has been found between higher IAP and urine volume (13, 16).

The results from data analysis indicated a significant correlation between the adequacy of urine volume and IAP. The rate of decrease in urine volume was less than 100 cc/h [5.2% (7 patients out of 135)].

In line with the present study, Murtaza et al (2015)(17) reported an increase of approximately 10–25% in IAP in 83 patients admitted to the internal care and surgical units ; it further reported the reduction of urine volume to less than 25 cc/h as a complication of IAP increase in the renal system. However, the

patients under study included 61% of internal patients and 39% of surgical patients; finally, patients with higher IAP had more complications than other patients. Despite the differences in research population, Murtaza et al. found results which are consistent with the present study, reflecting reduction of renal blood flow and glomerular filtration rate in the presence of IAP increase. In addition to reporting the incidence of IAP increase in kidney transplant patients in the present study, we investigated the diagnostic value of this method in the kidney transplant patients and sought to explain the predictive power of renal dysfunction by examining sensitivity and negative predictive value of IAP measurement method.

Additionally, the results of data analysis indicated a significant relationship between Delayed Graft Function and IAP. The results also showed that variables of renal dysfunction (creatinine deduction, need of dialysis in the first week of transplantation) were significantly correlated with IAP increase. That is to say, patients with IAP increase experienced one or all of the variables of renal dysfunction.

The results of the data analysis also indicated a significant relationship between the creatinine depletion of less than 25% of baseline and IAP, in the first week of transplantation. The incidence rate of creatinine depletion of less than 25% of baseline, in the first week of transplantation was 15% (20 out of 135 patients). Patients with creatinine depletion less than 25% of baseline, experienced a higher IAP mean. In a study by Biancofiore et al (2003) (9) on 108 liver transplant patients, the incidence rate of IAP increase along with renal insufficiency (creatinine increase) was reported to be 16%, while an increase of 32% was reported in IAP. Despite the difference in the research population, Biancofiore et al. reported the acceptable creatinine depletion to be less than 1.13mg/dl on the first three days after liver transplantation. They further determined the incidence rate of renal dysfunction within this range whereas this study examined renal transplant patients during the first week of transplantation; the incidence rate of renal dysfunction in the study by Biancofiore was in line with the present study.

Furthermore, results of data analysis indicated a significant relationship between the incidence of dialysis and IAP. The incidence of dialysis and need to take thymoglobulin due to renal insufficiency was 9% (12 out of 135 patients who required dialysis). The IAP mean was higher in patients in need of dialysis and thymoglobulin than other patients. In the study by Biancofiore (9), 2.7% of patients need dialysis (3 patients out of 108 patients).

Besides, the data analysis found a significant correlation between Doppler ultrasound and IAP. It meant that the incidence of increased vascular resistance in vascular Doppler ultrasound of transplanted kidney was 9.5% (13 patients out of 135 patients) in the present study; patients with higher vascular resistance in Doppler ultrasound experienced higher IAP on average than other patients.

According to a study by Coca et al (2018) (18) conducted on 41 kidney transplant from brain death patients, there was a significant relationship between Doppler ultrasound of the transplanted kidney and higher IAP. In their study, despite a smaller research sample than the present study, there was a significant relationship between Doppler ultrasound and higher IAP.

The *Thymoglobulin* intake was further a result obtained from evaluation of predicting renal adequacy in renal transplant patients. The rate of using *Thymoglobulin* due to the probability of renal dysfunction was 41.9% (57 out of 135 patients), and there was a significant relationship between IAP and *Thymoglobulin* intake. However, the patients who took *Thymoglobulin* experienced higher IAP on average than other patients.

In a review study by Alatab (2015) et al. (19), they investigated the therapeutic effect of *Thymoglobulin* in patients prone to transplant rejection. A retrospective study on high-risk patients indicated that the long-term survival of the transplanted organ was better in patients who received *Thymoglobulin* than the control group (19) ($p = 0.03$).

Thus according to the results of this study, The IAP measurement via bladder as diagnostic test showed a good negative predictive value to predict renal good function. But its sensitivity to predict renal dysfunction in kidney transplantation patients is less than Doppler ultrasound.

Conclusion

The results of the present study revealed that IAP measurement through bladder catheter was a nursing diagnostic method that could be performed by trained nurses and was able to predict renal accurate function. If a patient has normal IAP the nurse can predict that the kidney would not be in a danger. Ultrasound is a diagnostic method, which requires the appropriate equipment and expertise, but IAP measurement is an easy, accurate and accessible method which the nurse can continuously perform during the first days of transplantation, and it also can help the transplant team to diagnose early renal dysfunction with regard to creatinine, urinary, and IAP changes. Finally the results of this research showed the good progress in surgical technologies of kidney transplantation reduced the post-operative complications such as IAH (Intra-Abdominal Hypertension), Bleeding, renal dysfunction and ACS (Abdominal Compartment Syndrome). Thus to recommend the IAP measurement test via bladder in kidney transplantation patients we need more researches in multiple hospitals.

Declarations

Ethical considerations

The protocol of the present study have been approved by the ethical committee of Mashhad University of Medical sciences with the code of ethics (IR.MUMS.NURSE.REC.1397.081). At the first day of admission of each patient, the researcher talked to him and get him all of the information about the procedure of measuring the abdominal pressure via the bladder catheter, if the patient satisfied to participate in the research, the informed consent form was completed by the patient and kept by the researcher till now. The patient could leave the research whenever he wants. All of the Helsinki principle were considered in this research. The researcher explained to the patient that all of the data of all of the patients in this

research would be analyzed together, and the name of the patient would be confident. Thus the patient satisfied to publishing the results in the consent form.

Availability of Data:

The data in this research have been analyzed by Stata 14. If the reviewers want they can get access to the data.

Funding:

This research is extracted from a master thesis of critical care nursing, that is funded by the research deputy of Mashhad University of Medical Sciences, Mashhad, Iran.

Authors contributions:

The first author is the student, she was the key reasearcher who wrote the proposal of the research and did the sampling and wrote the first draft of the manuscript.

The second author is the supervisor t\of the thesis the conceptualization of the research has been done by her. She critically edited all of the formats of the manuscript and supervised the process of research (sampling and analyzing the data).

The third author is the advisor of the research. He is a methodologist. The process of the methodology, sampling and at last analyzing the data have been done by his supervision.

The forth author is an Urologist. The process of sampling and IAP Measurement has done in his supervision.

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Conflict of interest

There was no conflict of interest in the present study.

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Figures

Figure 1

The STARD flow diagram of the study

Figure 2

The intra-abdominal pressure (IAP) measurement procedure

Figure 3

ROC Curve 1- Relationship between abdominal pressure mean difference 1-4 and lack of 25% creatinine depletion during the first week after kidney transplantation

Figure 4

ROC Curve 2 - Relationship between the intra-abdominal pressure mean difference (1-4) and decreased urination less than 100 cc

Figure 5

ROC Curve 4 - Relationship between intra-abdominal pressure mean difference (1-4) with intravascular resistance according to Doppler Sonography

Figure 6

ROC curve- relationship between the IAP mean difference (1-4) with the frequency of dialysis and thymoglobulin intake after transplantation