ORIGINAL RESEARCH ARTICLE | UHD JOURNAL OF SCIENCE AND TECHNOLOGY

Advanced Methods for Detecting Pelviureteric Junction Dilatation by Two Dimensional Ultrasound

Heamn Noori Abduljabbar and Sardar Yaba Perxdr

Department of Physics, College of Education, Shaqlawa Slahaddin University, Erbil, Iraq

ABSTRACT

Pelviureteric junction (PUJ) obstruction is a condition frequently encountered in both adult and pediatric patients. Congenital abnormalities and crossing lower-pole renal vessels are the most common underlying pathologies in both men and women. There are different methods for detecting it the most usual, safe, and easy one is by ultrasound scanning. The aim of this study is how to improve the image quality of two dimensional (2D) ultrasound screening of detecting PUJ dilatation using image processing software, image enhancement, and different types of filters, then making comparison which filter is the best to improve the image quality, that helps the medical doctors, and sonographers to make the correct decision and diagnosis. 1357 patients scanned by ultrasound in Harer general hospital for general abdominal scanning, 987 cases among them have detected as urinary tract infection cases among this 987 case there were 73 case of them with PUJ dilatation. The 2D ultrasound images saved, after making image enhancement and using different types of filters (HE, ADH, CLAHE, and Wiener) to enhance four 2D ultrasound images of abnormal kidneys, the result was in each type of filters there were some advantages and disadvantages, so that the best type of filters are (HE and ADH) because the PUJ and pelvis is much more clear and easy to define after using these kinds of filters.

Index Terms: ADH, CLAHE, HE, Image Enhancement, Image Processing, Pelviureteric Junction, Wiener

1. INTRODUCTION

Ultrasound imaging regarded as a boon to study the internal tissues of a human body for different purposes, especially for the pregnant women because of its several advantages as comparing with computed tomography (CT), magnetic resonance imaging (MRI), and positron emission technology (Ransley 1990). However, it is consider as one of the best methods of diagnostic scanning tools but the presence of multiplicative speckle noise which is difficult to model in real time that affects the visual quality of the ultrasound images, especially in two dimensional (2D) ultrasound. The extensive research done by the researchers at device level led to the introduction of the three dimensional and four dimensional [3]. Ultrasound scanning is one of the best methods for detecting many diseases related to the internal organs, one of the most important defects that can be diagnosed clearly by ultrasound scanning is pelviureteric junction (PUJ) dilatation. Congenital and acquired (PUJ) obstruction can be treated with balloon dilatation, using a Fogarty/Gruntzig catheter introduced through the cystoscope in children.

Mahant *et al.* [4] stated that PUJ dysfunction is one of the common causes of renal hydronephrosis. Other causes, which are usually associated with hydroureter as well hydronephrosis, include bladder pathology vesicoureteric

Access this article online

DOI: 10.21928/uhdjst.v1n1y2017.pp33-37

E-ISSN: 2521-4217

P-ISSN: 2521-4209

Corresponding author's e-mail: heamn.abduljabbar@su.edu.krd

Received: 10-03-2017 Accepted: 25-03-2017 Published: 12-04-2017

obstruction and vesicoureteric reflux. Common causes of PUJ dysfunction include intrinsic stenosis is indicated in patients with pain, infection or hematuria, fever, back pain, dysuria, and hypertension in severe cases. Surgery may be performed open or laparoscopically.

2. ANATOMY

A. Location

Kidneys are located on the posterior abdominal wall, with one on either side of the vertebral column and perirenal space. Kidneys normally are lie on the quadratus lumborum muscles, the long axis of the kidney is parallel to the lateral border of the psoas muscle, and can be visualized in the first trimester by transabdominal scan at 12-13 weeks. In addition, the kidneys lie at an oblique angle, that is the superior pole is more medial and anterior than inferior renal pole. Right kidney usually lies slightly lower than left kidney due to the right lobe of the liver (Bems 2014).

B. Structure

Renal shape looks like a bean-shaped with a superior and an inferior pole. The mid portion of the kidney is often called the midpole. In adults, each kidney is normally weighs 150-260 g and 10-15 cm in length, 3-5 cm in width. The left kidney is usually slightly larger than right. Moreover, kidney has a fibrous capsule, which is surrounded by pararenal fat. The kidney itself can be divided into renal parenchyma, consisting of renal cortex and medulla, and the renal sinus containing renal pelvis, calyces, renal vessels, nerves, lymphatics, and perirenal fat. Renal parenchyma consists of two layers: Cortex and medulla. Renal cortex lies peripherally under the capsule while the renal medulla consists of 10-14 renal pyramids (renal filters), which are separated from each other by an extension of renal cortex called renal columns. Urine is produced in the renal lobes, which consists of the renal pyramid with associated overlying renal cortex and adjacent renal columns. Each renal lobe drains at a papilla into a minor calyx, four or five of these unite to form a major calyx. Each kidney normally has two or three major calyxes, which unite to form the renal pelvis, furthermore proximal ureter is connecte or started from renal pelvis which make a PUJ. The renal hilum is the entry to the renal sinus and lies vertically at the anteromedial aspect of the kidney. It contains the renal vessels and nerves, fat and the renal pelvis, which typically emerges posterior to the renal vessels, with the renal vein being anterior to the renal artery. Renal function is removing excess water, salts, and wastes of protein metabolism from the blood.

Diagnostic imaging of kidney:

- X-ray
- MRI
- CT scan
- Ultrasound.

3. METHODOLOGY

Ultrasound is used to detect urinary tract infections (UTI), one of the most important renal diseases is PUJ dilatation which can be defined by ultrasound clearly if the image quality is high, in this study 2D ultrasound used for scanning, the scanning procedure starts using convex probe (transducer), with 3.5 MHz frequency, time gain compensation total gain compensator should be adjusted according to each patient, then applying translucent gel to the patient abdominal skin who requested to be in supine position.

Scanning point for the kidneys starts from both sides of the abdomen, which called also upper loin, scanning windows should be from three points as general, anterioposterily, lateromedially, and posteriomedially. With oreintations and angulations to obtain the best image in which PUJ should be clearly defined. 1357 patients scanned by ultrasound in Harer general hospital/Erbil/Kurdistan/Iraq for general abdominal scanning, 987 cases among them have detected as UTI cases among this 987 case there were 73 case of them with PUJ dilatation. The 2D ultrasound images saved and transmitted to a computer to be processed by applying different types of filters to improve image quality, and finally comparing between filters types to choose the best type with best image quality of detecting PUJ dilatation. Different types of filters (HE, ADH, CLAHE, and Wiener) used to enhance 2D ultrasound images of (4) abnormal kidneys making image enhancement.

The contrast enhances techniques performed through some operations such as point operations are referred to as gray-level transformations or spatial transformations. They can be expressed as:

$$g(x,y) = T[f(x,y)] \quad (1)$$

Where g(x,y) is the processed image, f(x,y) is the original image, and T is an operator on f(x,y). Since the actual coordinates do not play any role in the way the transformation function processes the original image, equation (1) can be rewritten as:

$$s = T[r] \quad (2)$$

Where r is the original gray level of a pixel and s is the resulting gray level after processing.

Point transformations may be linear (e.g., negative), piecewise linear (e.g., gray-level slicing), or nonlinear (e.g., gamma correction).

Contrast adjustment is one of the most common applications of point transformation functions (also known by many other names such as contrast stretching, gray-level stretching, contrast adjustment, and amplitude scaling). One of the most useful variants of contrast adjustment functions is the automatic contrast adjustment (or simply autocontrast), a point transformation that—for images of class uint 8 in MATLAB—maps the darkest pixel value in the input image to 0 and the brightest pixel value to 255 and redistributes the intermediate values linearly. The autocontrast function can be described as follows:

$$S = \frac{L-1}{r_{max} - r_{min}}(r - r_{min}) \quad (3)$$

Where r is the pixel value in the original image (in the [0, 255] range), r_{max} and r_{min} are the values of its brightest and darkest pixels, respectively, s is the resulting pixel value, and L-1 is the highest gray value in the input image (usually L = 256). MATLAB has a built-in function imadjust to perform contrast adjustments.

Power law (gamma) transformations is given by the following transformation function:

$$s = c \bullet r^{\gamma} \quad (4)$$

Where r is the original pixel value, s is the resulting pixel value, c is a scaling constant, and γ is a positive value.

Histogram equalization is one of the well-known enhancement techniques. In histogram equalization, the dynamic range and contrast of an image is modified by altering the image such that its intensity histogram has a desired shape. This is achieved using cumulative distribution function as the mapping function. The intensity levels are changed such that the peaks of the histogram are stretched and the troughs are compressed. If a digital image has *N* pixels distributed in L discrete intensity levels and n_k is the number of pixels with intensity level i_k and then the probability density function of the image is given by equation (5). The cumulative density function is defined in equation (6):

$$f_i(i_k) = \frac{n_k}{N} \quad (5)$$

$$F_k(i_k) = \sum_{j=0}^{k} f_i(i_j) \quad (6)$$

Although this method is simple, since the gray values are physically far apart from each other in the image. Due to this reason, histogram equalization gives very poor result images (Sasi and Jayasree, 2013).

Adaptive Histogram Equalization (AHE) is a method of contrast enhancement. It is different from ordinary histogram equalization. In adaptive method, many histograms are computed where each histogram corresponds to a different section of image. Hence, AHE improves the local contrast of an image and more details can be observed. With this method, information of all intensity ranges of the image can be viewed simultaneously. There are many ordinary display devices that are not able to depict the full dynamic intensity range. This method brings a solution to this problem. Other advantages include that it is automatic (i.e., no manual intervention is required) and reproducible from study to study [DOI, Kunio 1996] (DOI 1996).

Apart from the advantage of local enhancement, AHE method has some limitations also. This method works too slowly on a general purpose computer although it works correctly. As enhancement is carried out in a local area, AHE tends to over enhance the noise content (Gupta and Kaur, 2014).

4. RESULT AND DISCUSSION

Four different types of filters used to enhance the images which are (HE, ADH, CLAHE, and Wiener) after image processing completed results showed that (HE, and ADH) is the best method to be used for detecting this renal problem as in (HE) filter PUJ, renal cortex, and renal pelvis is very clear to be defined in all of the images, furthermore using (ADH) PUJ, renal cortex and renal pyramids can be clearly defined. While pictures that used (CLAHE), and (Wiener) types of filter shows poor quality of the PUJ borders, and somewhat blurring with more noises compared with (HE and ADH). As the figures show in Fig. 1-8.

5. CONCLUSION

Image processing is a revolution in imaging as general, especially in the medical imaging due to the options that

Fig. 1. Original two-dimensional ultrasound image shows simple (mild) pelviureteric junction dilatation

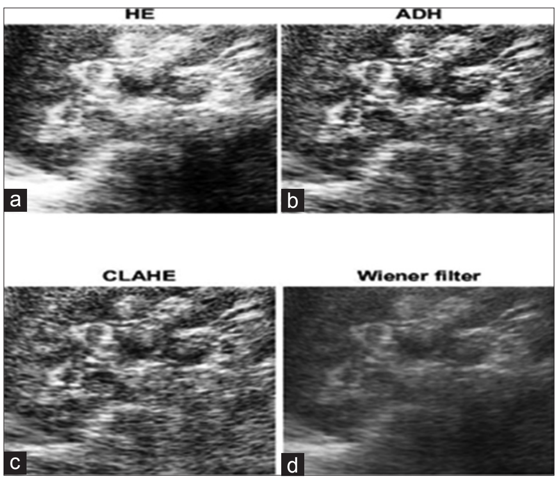

Fig. 2. (a-d) Image treated with the four filter types

Fig. 3. Original two-dimensional ultrasound image shows mild–moderate dilatation in pelviureteric junction

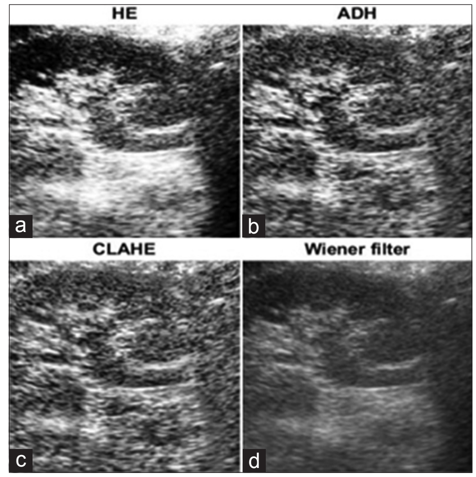

Fig. 4. (a-d) Image treated with the four filter types

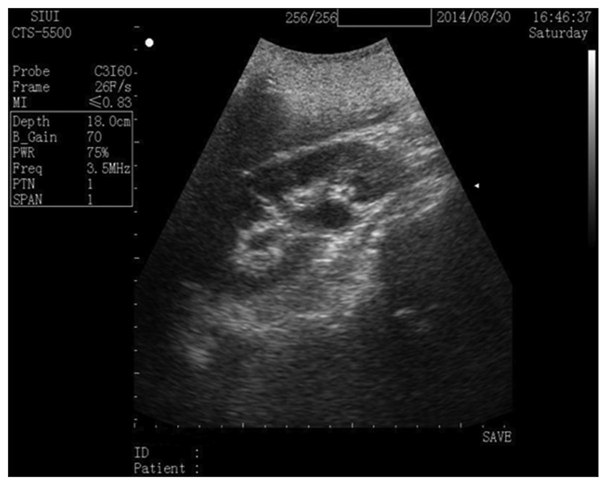

Fig. 5. Original two-dimensional ultrasound image shows moderate dilatation of pelviureteric junction

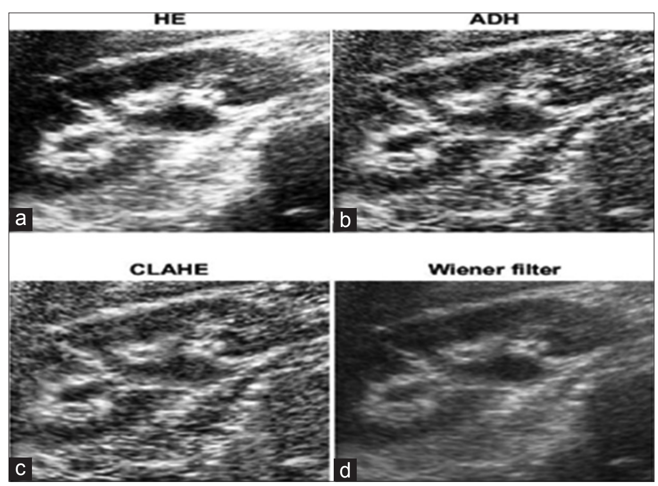

Fig. 6. (a-d) Image treated with the four filter types

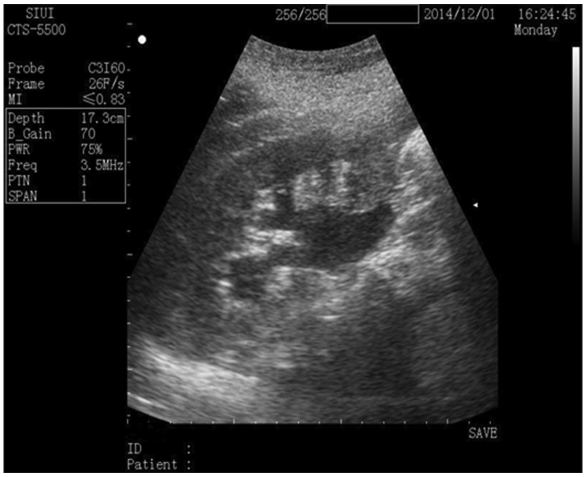

Fig. 7. Original two-dimensional ultrasound image shows sever dilatation in the pelviureteric junction

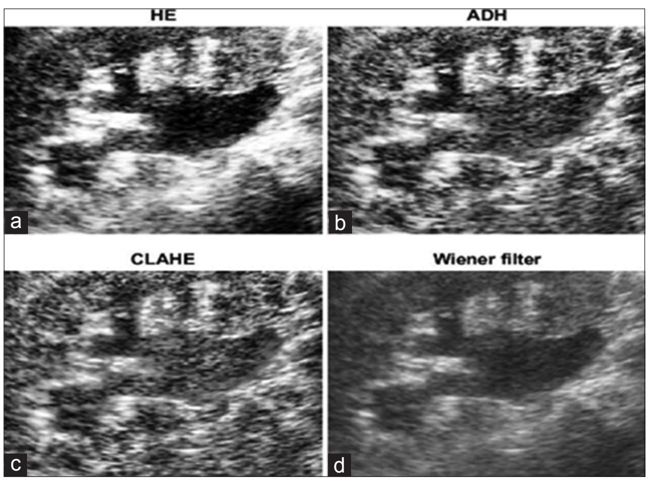

Fig. 8. (a-d) Image treated with the four filter types

provides to medical doctors and sonographers, so that in this study after saving 2D ultrasound images, different types of filters used to enhance those images, and improve its quality to be easier for diagnosis four different abnormal images of PUJ dilatation selected from all the patients who scanned, each case with different level of dilation from mild to moderate and sever.

REFERENCES

[1] J. R. Lindner, J. Song, F. Xu, A. L. Klibanov, K. Singbartl, K. Ley and S. Kaul. "Noninvasive ultrasound imaging of inflammation using microbubbles targeted to activated leukocytes." *Circulation*, vol. 102. No. 22, pp. 2745-2750, 2000.

[2] P. G. Ransley, H. K. Dhillon, I. Gordon, P. G. Duffy, M. J. Dillon and T. M. Barratt. "The postnatal management of hydronephrosis diagnosed by prenatal ultrasound." *The Journal of Urology*, vol. 144, pp. 584-587, 1990.

[3] T. D. Brandt, H. L. Neiman, M. J. Dragowski, W. Bulawa and G. Claykamp. "Ultrasound assessment of normal renal dimensions." *Journal of Ultrasound in Medicine*, vol. 1. no. 2, pp. 49-52, 1982.

[4] S. Mahant, J. Friedman and C. MacArthur. "Renal ultrasound findings and vesicoureteral reflux in children hospitalised with urinary tract infection." *Archives of Disease in Childhood*, vol. 86. No. 6, pp. 419-420, 2002.

[5] J. S. Berns, D. H. Ellison, S. L. Linas and M. H. Rosner. "Training the next generation's nephrology workforce." *Clinical Journal of the American Society of Nephrology*, vol. 9. No. 9, pp. 1639-1644, 2014.

[6] A. P. Barker, M. M. Cave, D. F. Thomas, R. J. Lilford, H. C. Irving, R. J. Arthur and S. E. Smith. "Fetal pelvi-ureteric junction obstruction: Predictors of outcome." *British Journal of Urology*, vol. 76. no. 5, pp. 649-652, 1995.

[7] R. Aviram, A. Pomeranz, R. Sharony, Y. Beyth, V. Rathaus and R. Tepper. "The increase of renal pelvis dilatation in the fetus and its significance." *Ultrasound in Obstetrics and Gynecology*, vol. 16. No. 1, pp. 60-62, 2000.

[8] H. P. Duong, A. Piepsz, K. Khelif, F. Collier, K. de Man, N. Damry, F. Janssen, M. Hall and K. Ismaili. "Transverse comparisons between ultrasound and radionuclide parameters in children with presumed antenatally detected pelvi-ureteric junction obstruction." *European Journal of Nuclear Medicine and Molecular Imaging*, vol. 42. no. 6, pp. 940-946, 2015.

[9] P. Masson, G. De Luca, N. Tapia, C. Le Pommelet, A. Es Sathi, K. Touati, A Tizeggaghine and P. Quetin. "Postnatal investigation and outcome of isolated fetal renal pelvis dilatation." *Archives de Pediatrie*, vol. 16. no. 8, pp. 1103-1110, 2009.

[10] C. Hong-Lin. "Surgical indications for unilateral neonatal hydronephrosis in considering ureteropelvic junction obstruction." *Urological Science*, vol. 25. no. 3, pp. 73-76, 2014.

[11] N. A. Patel and P. P. Suthar. "Ultrasound appearance of congenital renal disease: Pictorial review." *The Egyptian Journal of Radiology and Nuclear Medicine*, vol. 45. no. 4, pp. 1255-1264, 2014.

[12] K. Doi. "Current status and future potential of computer-aided diagnosis in medical imaging." *The British Journal of Radiology*, vol. 78. no. 1, pp. S3-S19, 2014.

[13] K. Doi. "Current research and future potential of computer-aided diagnosis (CAD) in radiology: Introduction to overviews at five institutions around the world." *Medical Imaging Technology*, vol. 14. no. 6, pp. 621, 1996.