

**EVALUATION OF NORMAL INFERIOR VENA CAVA DIAMETERS IN SAUDI  
POPULATION USING COMPUTED TOMOGRAPHY****Dr. Ahmad Abduljabar\*, Dr. Mohammad Wazzan, Dr. Sultan Mana Alamri and Dr. Alshimaa Ahmed Adas**

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**ABSTRACT**

Knowledge of the normal inferior vena cava (IVC) diameter among each particular population is essential for critical care physicians and surgeons. To date, there is a lack of published data about the normal IVC diameter in Saudi Arabia and, therefore, the aim of this study to evaluate the normal IVC diameter in Saudi population and to assess its correlation with demographic parameters. Methods: A retrospective chart review study was conducted on 400 patients who had helical computed tomography (CT) scans in King Abdul-Aziz University Hospital in Jeddah, Saudi Arabia during the period 2015-2017. Patients with cardiac diseases, hepatitis, or hepatic cirrhosis were excluded. Results: The mean age of the patients was  $51.8 \pm 16.9$  years. Females constituted 60% of the recruited patients. The IVC diameter ranged from 7 to 26 mm measured 3 cm above the bifurcation into an iliac vessels, 12 to 37 mm measured 2 cm above the renal veins and 8 to 27 mm at sagittal views. There was no statistically significant difference between males and females as regards the IVC diameter at different locations ( $p > 0.05$ ). The spearman coefficient correlating age and IVC diameter among males at 3 cm above bifurcation at AP diameter, 3 cm above bifurcation at transverse diameter and 2 cm above renal vein was  $r = 0.77, 0.87, \text{ and } 0.82$ , respectively. Conclusion: The mean IVC diameter among the Saudi population is comparable with literature study. No significant difference between males and females was revealed, but there is a strong positive correlation between age and IVC diameter among men.

**KEYWORDS:** Computer tomography, CT, diameter, inferior vena cava, Saudi population.**INTRODUCTION**

The diameter of the inferior vena cava is different among various populations, and it varies according to many factors such as respiratory cycle, position, hydration status, and age.<sup>[1],[2]</sup> For many physicians, knowledge of the average inferior vena cava diameter of the population they treat is essential in many situations. For instance, evaluation of inferior vena cava diameter denotes the hydration state in shocked patients and can provide a reliable predictor for volume status and central venous pressure.<sup>[1],[3]-[5]</sup> Furthermore, knowledge of the standard inferior vena cava diameter is useful in managing hepatic patients (such as liver cirrhosis) particularly those indicated for hepatectomy or other liver surgeries.<sup>[6],[7]</sup>

In Saudi Arabia, there is a lack of published data addressing the normal diameters of inferior vena cava among Saudi population. Several literature studies were concerned with the normal diameter of this vessel, and they reported that the normal diameters varied with age, gender, daily workload and geographic variation.<sup>[8]</sup> However, there is a lack of Saudi data concerned with the diameter of the inferior vena cava. Therefore, this study aimed to explore and evaluate the normal diameters of inferior vena cava in the Saudi population

using computed tomography (CT) and to assess its variation with several factors including age and gender.

**MATERIALS AND METHODS**

This is a retrospective chart review study conducted at King Abdul-Aziz University Hospital (KAUH) in Jeddah, Saudi Arabia during the period 2015-2017 after being approved by biomedical ethics unit. A total of 400 patients were included in this study. Patients at variable age groups who had helical contrast-enhanced computed tomography (CT) were eligible for inclusion. Patients with cardiac diseases, hepatitis, or hepatic cirrhosis were excluded from the study as these diseases are known to affect the inferior vena cava diameter.

Demographic data of all the included patients such as age and sex were reviewed, and the inferior vena cava diameter was measured using the CT scan via scrolling on SPECTRA workshop and taking the measures in axial, coronal and sagittal views. The measures were recorded at two different locations: 3 cm above the bifurcation and 2 cm above the renal vein.

For statistical analysis, gender was the only categorical variable, and it was presented as frequency and

percentage. Age and IVC diameters were presented as mean $\pm$ SD, SE, minimum and maximum values. Difference between continuous variables among both genders was tested using the independent samples t-test. Spearman rank correlation test was performed to test the correlations between age and IVC diameter at different levels among males and females. Finally, paired samples t-test was conducted to evaluate the statistical difference between the mean of IVC AP diameter 3 cm above the bifurcation and 2 cm about the renal vein. The same test was repeated to evaluate the statistical difference between IVC transverse diameter 3 cm above the bifurcation and 2 cm above the renal vein.

All data were adequately collected and fed to a computer, and there were no missing values. Hence, missing data management was not required. The analysis was conducted using Statistical Package for Social Science (SPSS), version 20 (IBM, Armonk, NY, USA) at 95% confidence interval.

## RESULTS

The age of the 400 recruited patients ranged from 15 to 115 years with a mean age of  $51.83 \pm 16.96$  years (table 1). Females constituted the vast majority (60.0%) of the recruited sample (figure 1). The mean $\pm$ SD IVC AP diameter 3 cm above the bifurcation and 2 cm above renal vein for all patients was  $1.68 \pm 0.02$  cm and  $2.06 \pm 0.02$  cm, respectively. The mean $\pm$ SD IVC transverse diameter 3 cm above the bifurcation and 2 cm above renal vein for all patients was  $2.00 \pm 0.01$  cm and  $2.34 \pm$

$0.02$  cm, respectively, and the mean IVC sagittal diameter among all patients was  $1.72 \pm 0.01$  cm (Table 1).

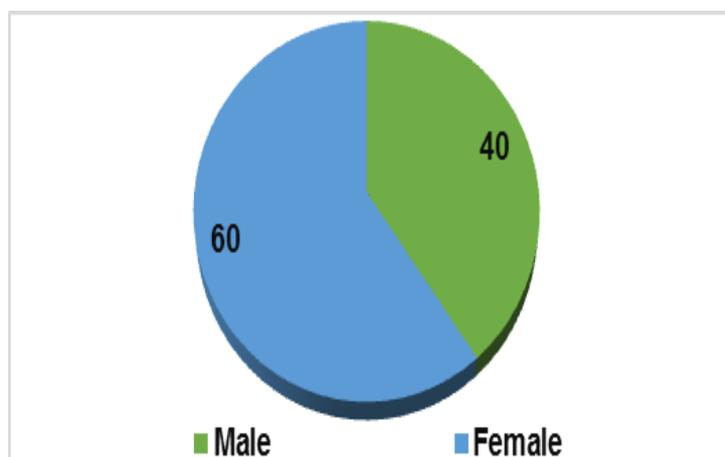
Upon comparing the different IVC diameters measured 3 cm above the bifurcation and 2 cm above the renal vein between males and females, there was no statistically significant difference between the two genders ( $p > 0.05$ ) (table 2). Also noted, there was no significant correlation between the patient age and inferior vena cava diameters at any view and at any level among males and females ( $p > 0.5$ ) (table 3). For the male population, age was seen to be strongly correlated with IVC AP diameter 3 cm above bifurcation ( $r.768$ ), IVC transverse diameter 3 cm above bifurcation ( $r.820$ ) and IVC AP diameter 2 cm above renal vein ( $r.872$ ). The correlations between age and IVC diameter were statistically significant ( $P < 0.05$ ). For the female population age was not strongly correlated with any of the IVC diameters, however, IVC sagittal diameter was correlated with the age at moderate strength ( $r.599$ ). All the correlations are given in table 3.

Paired samples t-test revealed a statistically significant difference between IVC AP diameter 3 cm above bifurcation and IVC AP diameter 2 cm above renal vein ( $t -21.859$ , 95% CI  $-0.35-0.42$ ,  $p < .001$ ). Similarly, there was a statistically significant difference between IVC transverse diameter 3 cm above bifurcation and IVC transverse diameter 2 cm above renal vein ( $t = -18.517$ , 95% CI  $-0.30-0.37$ ,  $p < .001$ ) (Table 4).

## TABLES AND FIGURES

**Table 1: Age and IVC measurements of all patients presented as mean, SE, SD, Min and Max values. (n = 400).**

	Mean	SE	SD	Min	Max
Age	51.83	0.85	$\pm 16.96$	15.00	115.00
IVC AP diameter 3 cm above bifurcation	1.68	0.02	$\pm 0.30$	0.70	2.60
IVC transverse diameter 3 cm above bifurcation	2.00	0.01	$\pm 0.29$	0.80	2.70
IVC AP diameter 2 cm above renal vein	2.06	0.02	$\pm 0.37$	1.20	3.60
IVC transverse diameter 2 cm above renal vein	2.34	0.02	$\pm 0.36$	1.40	3.40
IVC sag diameter	1.72	0.01	$\pm 0.28$	0.80	2.70



**Figure 1: Gender distribution of all patients (n = 400).**

**Table 2: Age and IVC diameter distribution among males and females and comparison both gender by independent samples t-test (n = 400).**

	Males (n = 42)	Females (n = 56)	Independent samples t-test results		
	Mean ± SD	Mean ± SD	F	95% CI	p-value
Age	51.70 ± 18.12	51.92 ± 16.18	3.587	3.19-3.62	.901
IVC AP diameter 3 cm above bifurcation	1.71 ± 0.31	1.66 ± 0.30	0.779	0.11-0.01	.132
IVC transverse diameter 3 cm above bifurcation	2.01 ± 0.27	2.00 ± 0.30	2.512	0.06-0.05	.907
IVC AP diameter 2 cm above renal vein	2.06 ± 0.37	2.06 ± 0.37	0.111	0.07-0.07	.997
IVC transverse diameter 2 cm above renal vein	2.34 ± 0.34	2.33 ± 0.37	0.451	0.08-0.06	.834
IVC sag diameter	1.75 ± 0.27	1.71 ± 0.29	0.009	0.09-0.02	.191

**Table 3: Correlation between age and IVC measurements among males and females.**

		Spearman's rho		
		Male (n = 160)	Female (n = 240)	P- value
Correlation between age and -IVC	IVC AP diameter 3 cm above bifurcation	.768	.328	
	IVC transverse diameter 3 cm above bifurcation	.820	.334	
	IVC AP diameter 2 cm above renal vein	.872	.344	
	IVC transverse diameter 2 cm above renal vein	.612	.330	
	IVC sag diameter	.366	.599	

**Table 4: The mean difference between IVC diameters (AP and transverse) in different levels.**

	MD	t	95% CI	p- value
Difference between IVC AP diameter 3 cm above bifurcation and IVC AP diameter 2 cm above renal vein	-0.38 ± 0.35	- 21.859	-0.35-0.42	<.001
Difference between IVC transverse diameter 3 cm above bifurcation and IVC transverse diameter 2 cm above renal vein	-0.33 ± 0.36	- 18.517	-0.30-0.37	<.001

## DISCUSSION

The normal inferior vena cava diameter (IVC) 3 cm from the left atrium reported in literature among western populations ranges from 15 to 25 mm<sup>[9],[10]</sup> Studies from southeast Asian population reported closely similar values. For instance, a study conducted on 4126 Indian adults showed that the IVC diameter ranged from 4.6 to 22.6mm.<sup>[11]</sup> In this study, the diameter of IVC among Saudi population ranged from 7 to 26 mm 3 cm above the bifurcation, 12 to 37 mm 2 cm above the renal veins, and 8 to 27 mm at sagittal views. The range is wider than what is reported in the literature because we included patients from different age groups, i.e., from 15 to 115 years not only the adult population. In literature, the values evaluated in adult population were reported to range from 15 to 25 mm in individuals with euvolemic states, whilst values outside this range denoted states of hypovolemia (when IVC diameter fell below 15 mm) or hypervolemia (when IVC diameter exceeded 25 mm). In children, the IVC diameter measured in the sagittal plane ranged from 4 to 21 mm.<sup>[2],[12]</sup>

Many factors were reported to affect the IVC diameter such as age, euvolemic state, height, body mass index, and respiratory cycle phases.<sup>[8],[11],[13]-[15]</sup> In this study, we evaluated the impact of gender difference and age variation on the diameter of inferior vena cava among Saudi population. In females, we found that the diameter of IVC was 1.66±0.3 mm, 2.0±0.3 mm, 2.06±0.37 mm,

2.33±0.37 mm, and 1.71±0.29 mm at 3 cm above bifurcation AP, 3 cm above bifurcation transverse, 2 cm above renal veins AP, 2 cm above renal veins transverse, and sagittal views, respectively. Whilst in males, the mean IVC diameter was 1.71±0.31 mm, 2.01±0.27 mm, 2.06±0.37 mm, 2.34±0.34 mm, and 1.75±0.27 mm at 3 cm above bifurcation AP, 3 cm above bifurcation transverse, 2 cm above renal veins AP, 2 cm above renal veins transverse, and sagittal views, respectively. However, the differences between both genders were not statistically significant (P>0.05). This was similar to several literature studies that indicated there was no considerable gender impact on the IVC diameter.<sup>[10],[15]</sup>

As regards the age, this study revealed that there was a strong positive correlation between patient age and IVC diameter particularly among males at specific sites. A strong correlation was demonstrated between age and IVC diameter among males at 3 cm above bifurcation at AP diameter (r=0.77), 3 cm above bifurcation at transverse diameter (r=0.82), and 2 cm above renal vein (r=0.87) (p<0.05). The correlation between age and IVC diameter among females was less strong. Many literature studies were in agreement with these results. For instance, Kathuria *et al.*, in their study on 63 children at variable age group, reported that there was a significant positive correlation between the child's age and the IVC diameter with a spearman coefficient of 0.81, 0.79, and 0.79 for the maximum IVC sagittal diameter, minimum

IVC sagittal diameter, and maximum IVC transverse diameter, respectively.<sup>[2]</sup> Also, Masugata *et al.*, studying 200 patients at ages ranging from 17 to 94 years, reported a significant decline in inferior vena cava diameter with advanced age ( $r=-0.221$ ,  $p=0.002$ ).<sup>[16]</sup>

Of note, there was a significant difference between the anteroposterior diameter of inferior vena cava measured at 3 cm above bifurcation and the anteroposterior diameter measured at 2 cm above renal veins ( $P<0.001$ ). Similarly, there was a significant difference between the transverse diameters measured at those two sites ( $p<0.001$ ). This is important for surgeons and critical care physicians to be accurate at the location of measurement of inferior vena cava diameters for pre and postoperative comparisons of the vessel diameter.

### CONCLUSION

The inferior vena cava diameter among the Saudi population ranges from 7 to 27 mm in various planes. The diameter differs significantly on CT scan levels 3 cm above the bifurcation and 2 cm above the renal vein, and there is a significant positive correlation between age and IVC diameter particularly among males. However, there are no considerable statistical differences among the IVC diameters between males and females.

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