Comparison of Capability Analysis of Cumulative Cardiac Thoracic Ratio (CTR) Outputs

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Abstract

This study investigated the Capability Process Analysis of cumulative Cardiac Thoracic Ratio (CTR) during Radiological Chest Examination using MX.4 Radiological Diagnostic Machine (DRM) at the Fate Medical Foundation Radiological Department, Auchi. The data for the study are classified as raw and simulated CTR values. Statistical process control was investigated to address process stability and capability analysis was performed for the two processes. The pattern of the means of the raw and simulated values was investigated using normal probability plots and empirical CDF functions. The raw computed CTR values and simulated CTR values confirmed that the system is operating under 1.0 â?? 1.3 sigma level for the raw CTR values. Around 28-39

Index terms— algorithms, capability plot, CTR, mx.4 DRM x-ray, heart failure.

1 Introduction

dvance knowledge has made the study of process capability analysis not limited to the industry or manufacturing process only but is gaining overwhelming application in other fields of human endeavour especially in medicine for the evaluation of health care performance such as surgical site control, infection rate, response of patient to change in treatment in the hospital, outbreak of epidemic and performance of a forecasting system related to medical studies such as heart false positive radiological examination. This study looks at the process monitoring of CTR output measurements and check its state of stability for abnormality detection.

In medicine, chest radiography is commonly called chest X-ray (CXR). It is a projection of radiography of the chest use to diagnose conditions affecting the chest, its contents and nearly structure. Ribeiro, Jose, Renato, Roberto, Francisco, Domingo, and Beatriz (2012) observed that chest radiography is among the most common films taken to diagnose many conditions. Like all methods of radiography, chest radiography employs ionizing radiation in the form of xrays to generate images of the chest **??**Ribeiro, et al. (2012).

This research is motivated by the real life application of process capability analysis in the output of Cardio Thoracic Ratio of chest X-ray measurements in the examination of radiological process to establish capability analysis of the CTR experimental values. The aim of this study is to determine the capability analysis of Radiological CTR experimental values and the simulated values. The Specific objectives of the research are:

? To do capability analysis for experimental (Raw) and Simulated Cardiac Thoracic Ratio (CTR) values.

? To compare the capability analysis of the experimental Cardiac Thoracic Ratio (CTR) data (Raw values) and the simulated Cardiac Thoracic Ratio (CTR) data.

? To examine the significant difference in the variance of Cardiac Thoracic Ratio (CTR) data of raw and simulated CTR values. II.

2 Literature Review

The most commonly and widely used indices are p C (Juan 1974), pk C (Kane 1986), pm C (Hsiang and Taguchi 1985) and pmk C (Choiward and Owen 1970; Pearn and Kotz and Chen 1994-95) and their generalization for non-normal process suggested **??**Pearn and Kotz, 1995;Pearn and Chen 1995). Mukherjee (1995) studied conceptual

approaches to process capability analysis. A number of new approaches to process capability analysis have been attempted and experimented (Carr 1991; **??**laig 1996). Another index is given by Boyles (1994), when researcher or quality control officer is confronted with processes described by a characteristic whose values are discrete. Therefore, in such cases none of these indices can be used. The indices suggested so far whose assessment is meaningful regardless of whether the studied process in discrete or continuous are those suggested by **??**eh and Bhaltachiya (1998). Borges and Ho (2001), Perakis and Xekalaki (2002;2005) In this study, evaluation of cumulative capability characteristics of the experimental CTR values (Raw) and Simulated CTR values using uniform distribution are investigated.

In real life application, calculation of proposed capability index boils down to computation of the process yield. To evaluate the process yield, it is necessary to apply a curve fitting method to approximate the quality characteristic distribution ( ) x f . Polansky (1999) used non-parametric approach particularly Kernel density estimation to estimate process yield for both univariate as well as multivariate quality characteristics. Ciarlini, Gigli and Regoliosi (1999) used bootstrap methodology to estimate failed probabilities even in regions not supported by data with accuracy. Independent of the sample variances is useful when data are not nearly normal. The Pearson distribution was implemented (Clement 1989), the Johnson distribution was suggested (Chou and Polansky 1996;Chou, Polansky and Mason 1998;. Burr distribution was used to describe non-normal process data **??**Castaghola 1996).

In practice, one may often be faced with processes whose distributions are far from being normal. In this capability study the index and the assumption that the underlying distribution of the examined process is a non-normal form and in particular, exponential. Gunter (1989) observed the experimental distribution arises frequently in industrial processes and were explained in the article **??**Yeh and Bhattachayya 1998). The normal and exponential process index is achievable for continuous process however; they are useless when the process is discrete. Poison process index pk C is used in the assessment of discrete process. The properties of are examined in the case where the studied process is described by a poison distribution characteristic with parameter m>0. The uniform process index is achievable for continuous process however; it is useful when the process was discrete. Uniform process index pk C is used in the assessment of discrete process. The properties of pk C are examined in the case where the studied process is described by a uniform distribution characteristic with some parameter a and b (Maiti etal., 2009).

In this study chart such as histogram with normal distribution is used to detect the trend behaviour of the CTR distribution outlier for abnormal CTR values. Uniformly simulated data will be compared with the raw CTR values based on capability analysis and variance. Uniform distribution process is simulated to compare with the raw CTR value of chest radiological examination in this study.

3 IV.

4 Simulation Technique

Simulation provides a method for checking your understanding of the world around you and helps us to produce better results faster.

5 a) A Study Simulation

In the study of Cardiac Thoracic Ration of Chest X-ray films examination, the raw values of cardiac and thoracic measure shall be computed to obtain the CTR value of patients that undergo the Chest X-ray examination as:V V T C CTR = (1)

where V C is the cardiac value and the V T is the thoracic value of the measurements. If the CTR=0.5, the reading is said to be normal with boundary allowances of 0.45 and 0.55 for error of readings accommodation. Hence, the tolerance values are USL=0.55 and LSL=0.45 with the target value? ? ? ? ? ? + = 2 LSL USL T =0.5.

()**2**

The study employs simulation technique using

6 Design and Implementation of Simulation

The simulation use in this study follows a uniform distribution process which ranges from 0.43 to 0.71 with 5 number of variable as subgroup measurements for 150 sample random number all together making 750 observations. Excel application package is the implementation medium used for the random number generation.

7 VI.

8 Variance ctr Raw and Simulated Processes Comparison

Bartlet 'b'-statistic is assumed as test-statistic that is distributed approximately as ? 2 ? distribution when samples are independently drawn from normal population (Singha, 2002). We test that2 2 0 : s r H ? ? = and 2 2 0 : s r H ? ? ?

to determine equality of variances (Gomez and Kwanchai, 1984) of both raw and simulated CTR values of Chest X-ray measurement. Comparison of the variances of the raw CTR and Simulated CTR value is carried out in this study to investigate the process equality of variances. In this study, the variance of the CTR raw and simulated values are computed and tested for homogeneity based on the Bartlet Test 'b' statistic. The algorithm for the procedure is described by the following algorithm steps (A4).

9 VII.

10 Research Method

The source of data for the analysis is primary through raw computation and computer simulation using uniform distribution. The raw data are generated through the measurement values of the cardiac and thoracic of films output of Chest X-ray of patients from the radiological machine process. The ratios of the measurements are computed to obtain various CTR values over time. Inspection Coding Sheet (ICS) is used to randomly generate the samples for the study. Limits are set equal to 3sigma as

11 5

. 0 = T is based on the specification criteria for non-sensitivity analysis (specificity) while statistical process control is investigated to address process stability. Capability analysis is performed for the two processes. The pattern of the means of the raw and simulated values are detected using exploratory data Analysis (EDA) approach like normal probability plots, empirical CDF functions and Box-plot. In addition, homogeneity of variance of the two processes is investigated based on Bartlet's 'b' statistic. The analysis of data is performed electronically with the aid of statistical software MINITAB version 16.0.

12 VIII.

13 Data Analysis and Result

This aspect focuses on exploring data analysis behaviour pattern of Raw and Simulated Cardiac Thoracic Ratio (CTR) values. It also discusses control chart graphs, process capability analysis and the process variance comparison using Bartlet 'b' statistic. The Boxplot of RCTRv and SCTRv illustrate non deviation in the RCTRv but deviation exists in the SCTRv because of the existence of the spike (whiskers of dispersion). This confirms that there is likelihood of more deviation from the 0.5 CTR standard in the SCTRv compare to the RCTRv.

14 Xbar Chart of Mean

15 Figure 1a

From the fig1a, the aggregate observation of 150 samples indicates that all points of the raw CTR values are falling within control limit confirming the process statistical stability and under control with predicted trend of sensitivity.

16 Process Capability of Mean

(using 95.0% confidence)

17 Figure 1b

For sample 150, the mean estimated is 0.5654 where the within and overall standard deviation are 0.0222 and 0.0227,

18 Xbar Chart of Mean

19 Figure 2a

From the fig2a, cumulative 150 samples all points of the simulated CTR values are falling within control limits implying process stable and follow a predictable trend. .This implies that the process is using about 39.1% of the specification band.

Hence, the values of The average estimated value of CTR is 0.57 which is 0.02 higher than the upper specification limit. True sensitivity analysis value of about 59.9% is confirmed fail points among the examined patients while the deviation among the sample measures is 0.023. Both p C and p P are near approximate hence there is little between subgroup variability.

20 g) Bartlet Test 'b' Statistic Computation and Result

The computational result of the Bartlet Test 'b' Statistic value do not exceed the Chi-square value, the variance of the raw and the simulated CTR values have unequal variance.

21 IX.

22 Conclusion

After aggregating all the raw computed CTR values and simulated CTR values obtained, it is empirically confirmed that the system is operating under 1.0 -1.3 sigma level for the raw CTR values. Around 28-39% of the raw CTR values obtained are falling outside the specification limits and 30-45% of the specification band is being used. In addition, the p pk C C < for all the cumulative raw CTR values suggesting that the process is off centred and is towards the lower specification limit. Therefore, the points are falling outside the upper specification limit which clearly indicates that the variability in the raw CTR process is very high.

23 X.

24 Recommendation

Based on the empirical outputs of capability analysis of radiological result of CTR values (raw and simulated), this study therefore recommends that health awareness campaign on slow death resulting from heart failure as a result of absence of early detection of abnormal CTR value among patients should be created by the government and health agencies. Patients should be medically advised on the measure to control and maintain stable CTR. Also on how to adopt better management methods which can subsequently prevent possibility of high CTR and further study should be conducted on large repeated experimental scale to ascertain the reliability of this study. Fellow up study of patients should be undertaken by the cardiologist to reduce the possible health risk that could result from the CTR.

for each sample subgroups respectively.

Step 2 : Calculated the row total values ? = n i i x 1 and the row average value of the sample subgroups and the mean of the mean of sample subgroup as:? = ? = n i i x n X 1 1

and? = = = M j j X M X 1 _1

Step 3 : Calculate the sample range and the sample subgroup range;i i i x of MinValue x of MaxValue R ? = and ? = ? = M j j j R M R 1 1

Step 4 : Compute the sample variance and standarddeviation 2 1 1 ? = ? ? ? ? ? ? ? ? ? = n i i X X n ?

Step 5 : Evaluate the limits USL, CL and LSL for the sample mean? = + = R A X USL 2 ? = ? = R A X LSL 2 = = X CL

Step 6 : Evaluate the limits USL, LSL and CT for the sample range for = 0.577, , when n=5 from the SQC table readings. ? = R D USL 4 ? = R D LSL 3 ? = R CL for 2 A = 0.? = ? ? ? ? ? ? ? ? = n i i X X n s and 2 1 2 2 1 ? = ? ? ? ? ? ? ? ? = n i i X X n s

Step 3 : Calculate the ( ) ... 2 , 1 1 2 2 = ? ? = ? i K N S n S i i Step 4 : Compute ( ) ( ) ? ? ? ? = 2 2 log 1 log i i S n S k n Q Step 5 : Calculate ( ) ( ) ( ) ? ? ? ? ? ? ? ? ? ? ? + = ? K N n k H i 1 1 1 1 3( ) K N S n S i i ? ? = ? 2 2 1 = ( ) ( ) K N S n S n ? ? + ? 2 2 2 2 2 1 1 1 = ( )( ) ( )( ) = ? ? + ? 5 1500 193 . 1 1 5 674 . 0 1 5 0.0515 ( ) ( ) ? ? ? ? = 2 2 log 1 log i i S n S k n Q = ( ) ( ) ( )( ) ( )( ) [ ] 193 . 1 4 674 . 0 4 0515 . 0 log 2 5 + ? ? Q = ( )( ) [ ] 4675 . 7 2882 . 1 3 ? ? = -11.3321 ( ) ( ) ( ) ? ? ? ? ? ? ? ? ? ? + = ? K N n k H i 1 1 1 1 3 1 1 = ( ) ( )( ) ( ) ? ? ? ? ? ? ? ? ? ? + 5 150 1 4 4 1 1 2 3 1 1 H = ( ) ( ) 006896 . 0 0625 . 0 33 . 1 145 1 16 1 3 1 1 ? = ? ? ? ? ? ? ? + =0.07395 H Q b 3026 . 2 = = ? ? ? ? ? ? ?**07395** [1] [2]

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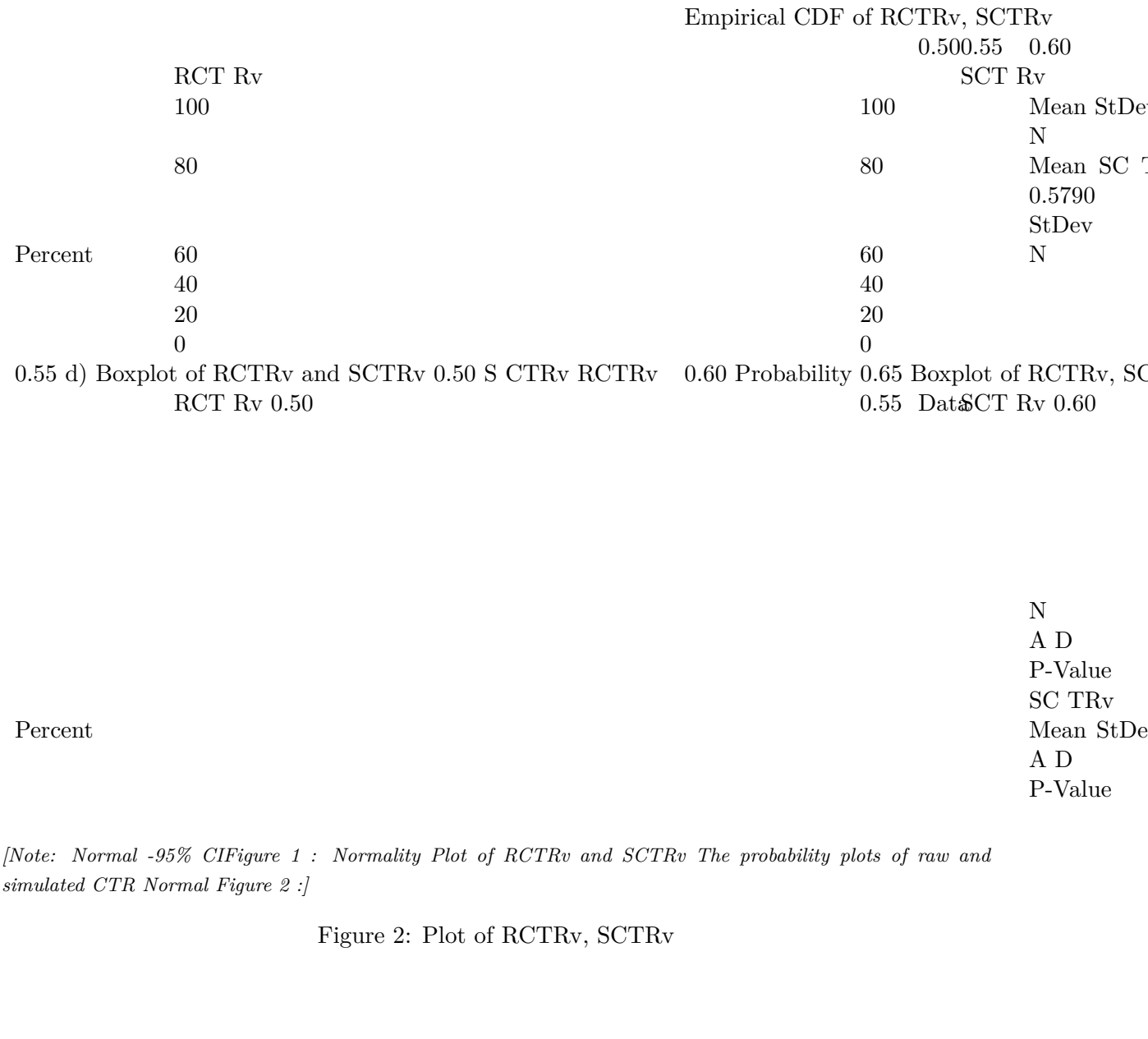
[2] ? value, both processes do not have equal variance.© 2014 Global Journals Inc. (US)

Figure 1: (



[Note: Normal -95% CIFigure 1 : Normality Plot of RCTRv and SCTRv The probability plots of raw and simulated CTR Normal Figure 2 :]

Figure 2: Plot of RCTRv, SCTRv

1

P rocess D ata

LS L 0.45

T arget U S L S ample M ean S ample N S tD ev (Within) S tI

Year
2014
48

P P M < LS L O bserv ed P erformance 0.00 P P M > U S L 7

2

			Simulated Cardiac Thoracic Ratio Value (SCTRv)
	n		25
	µ		0.5651
?			0.0422
	C	p	2.21
	C	pk	-2.14
	C	pm	1.07
	p P		2.09
	? p 1 C	?	0.4516
	?	?	
	?	?	
	?	?	
	P =	? 1 p C	
		?	
		?	
		?	
	p C ?		p P

Source: Results extracted from Minitab 16.0

For cumulative sample 150, the mean estimate is 0.5790 where the within and overall standard deviation are 0.0289 and 0.0290,

C pm= . 1 12 since the

centred and is toward the lower specification limits. The percentage of the specification band that the process uses up is P = 1 (/ C

that the process is using about 39.1% of the specification band. Values of p C and p P are barely equal hence there is substantial between subgroup variability.

For the total sample 150, the mean value estimated is 0.5790 where the within and overall standard deviation are 0.0289 and 0.0290,

C pk= 49 . 1 ? , C pm =

Compute b

A4 : Bartlet 'b' Statistic computational results for Raw and Simulated CTR values

Raw CTR		Variance	Simulated CTR		Variance
1 s	2	0.674	s	2 2	1.193
1 log s	2	-0.172	log s	2 2	0.0765

Figure 5:

Appendix B

B3

	0.003	0.010	0.005	0.005	0.009	0.010	0.009	0.010	0.011	0.010	0.007	.	.	0.006	0.011	0.010	0.001	0.007	0.006	0.0
	0.14	0.21	0.19	0.17	0.22	0.22	0.23	0.24	0.26	0.22	0.18	.	.	0.21	0.25	0.24	0.06	0.18	0.2	0.2
Year	3.07	2.76	2.73	2.55	2.5	2.84	2.79	3.05	2.65	3.06	2.69	.	.	2.86	2.95	2.78	2.86	2.87	2.77	2.8
2014	0.61	0.55	0.55	0.51	0.5	0.57	0.56	0.61	0.53	0.61	0.54	.	.	0.57	0.59	0.56	0.57	0.57	0.55	0.5
XIV	0.64	0.65	0.55	0.6	0.64	0.45	0.49	0.48	0.45	0.62	0.64	.	.	0.55	0.53	0.68	0.56	0.47	0.51	0.6
Is-	0.65	0.57	0.64	0.56	0.42	0.47	0.68	0.67	0.51	0.7	0.62	.	.	0.54	0.67	0.62	0.58	0.65	0.54	0.5
sue	0.59	0.64	0.56	0.43	0.47	0.63	0.45	0.72	0.54	0.52	0.51	.	.	0.68	0.73	0.51	0.59	0.61	0.61	0.5
I	0.66	0.47	0.54	0.48	0.42	0.68	0.55	0.64	0.44	0.51	0.46	.	.	0.47	0.48	0.43	0.54	0.63	0.66	0.4
Ver-	0.52	0.43	0.44	0.48	0.54	0.61	0.62	0.54	0.7	0.72	0.47			0.62	0.54	0.53	0.6	0.5	0.46	0.5
sion																				
I																				
54																				
I (	0.013	0.005	0.008	0.013	0.009	0.007	0.008	0.001	0.006	0.007	0.006	.	.	0.005	0.001	0.002	0.002	0.008	0.007	0.0
)	1	2	3	4	5	6	7	8	9	10	11	.	.	137	138	139	140	141	142	143
Vol-	0.71	0.73	0.74	0.78	0.6	0.73	0.71	0.51	0.68	0.64	0.5	.	.	0.64	0.61	0.46	0.55	0.74	0.71	0.6
ume	0.7	0.59	0.57	0.68	0.69	0.55	0.61	0.59	0.54	0.61	0.52	.	.	0.72	0.58	0.52	0.5	0.64	0.66	0.6
Global	0.76	0.56	0.63	0.52	0.51	0.57	0.46	0.57	0.48	0.56	0.66	.	.	0.53	0.57	0.53	0.5	0.5	0.51	0.5
Jour-	3.25	3.23	3.13	3.11	3.05	2.99	2.94	2.71	2.87	3.02	2.76		.	3.1	3.03	2.59	2.71	3.03	3.08	3
nal	0.65	0.65	0.63	0.62	0.61	0.6	0.59	0.54	0.57	0.6	0.55			0.62	0.61	0.52	0.54	0.61	0.62	0.6
of	0.29	0.17	0.23	0.27	0.2	0.21	0.25	0.09	0.2	0.21	0.18			0.19	0.08	0.11	0.1	0.24	0.2	0.1
Re-	Sam-	2	3	4	5	6	7	8	9	10	11			137	138	139	140	141	142	143
search	ples	0.65	0.67	0.51	0.72	0.63	0.6	0.53	0.54	0.71	0.61			0.59	0.66	0.57	0.6	0.58	0.66	0.6
in	Sub	0.7	0.51	0.63	0.53	0.52	0.56	0.52	0.63	0.49	0.48			0.62	0.62	0.5	0.57	0.57	0.54	0.5
En-	1 1																			
gi-	0.62																			
neer-	0.47																			
ing																				

Figure 6: Sub 2 Sub 3 Sub 4 Sub 5 Total Mean Range Sample Sub 1 Sub 2 Sub 3 Sub 4 Sub 5 Total Mean Range Variance

Figure 7: ray Radiological Readings 2011 Source: Chest X-ray Radiological Simulation Readings 2011 Raw Computed Data Simulated Cardio-Thoracic Ratio Using Uniform Distribution Radiographic Films Readings of Chest X-ray Radiographic Films Readings of Chest X-ray For congestive Heart Failure Cardiomegaly Conditions For congestive Heart Failure Cardiomegaly Conditions Cadio-Thoracic Ratio Variance Cadio-Thoracic Ratio

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