

# The importance of American College of Radiologists' (ACR) compliance with respect to imaging and intervention protocols for reducing in-hospital mortality rate due to the aortic aneurysm

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## RESEARCH

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## ABSTRACT

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### Background

There is no direct evidence from the available literature on whether aneurysm mortality rates in hospitals decreases if they comply with American College of Radiologists' (ACR) guidelines on diagnostic imaging and treatment interventions. This study investigated on the possibility of increasing ACR compliance levels progressively reducing in-hospital mortality rates of aneurysm patients.

### Aims

The study was aimed at examining whether the mortality rates of aortic aneurysm patients in hospital decrease if the hospitals comply with ACR guidelines on diagnostic imaging and treatment interventions. The second aim was to test the assumption that increasing compliance levels will progressively decrease the in-hospital mortality rate.

### Methods

Data on 36,104 net samples of patients collected from NIS data covering 47 US hospitals based on ICD-9 classification

were collected for the period of 2008–2012. The collected data were analysed for effect of ACR compliance of imaging methods and a modified ACR appropriateness rating on mortality rates of six major types of aortic aneurysm patients. Pearson's Chi-Square test, Gamma Correlation test and Logistic Regression test were done using the latest version of SPSS software. A predictive probabilistic equation for odds relationship of ACR compliance with mortality rate was also developed.

### Results

A large majority of US hospitals did not fully or partially comply with ACR guidelines. Clear evidence of increasing compliance level with ACR guidelines on both imaging methods and appropriateness rating on reduction of in-hospital mortality rates were obtained. There was negative relationship between compliance level and mortality rate. The relationship was linear and not affected by other predictors. This negative relationship reflected in the predictive equation. Therefore there is a strong case for hospitals implementing full compliance with ACR guidelines.

### Conclusion

The overall conclusion is that there is negative relationship between ACR compliance level and in-hospital mortality rate of aortic aneurysm patients. Increasing levels of ACR compliance progressively decreased in-hospital mortality rates, although this relationship may not be cause-effect relationship. Policies for implementing full ACR compliance by hospitals may reduce in-hospital mortality rate of aneurysm patients significantly.

### Key Words

ACR guidelines, aneurysm, in-hospital mortality, rating scale, compliance

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### What this study adds:

#### 1. What is known about this subject?

The ACR has recommended certain protocols for imaging

and interventions to reduce the mortality due to aortic aneurysms to be followed by all US hospitals.

## 2. What new information is offered in this study?

This paper provides some direct evidence for progressive decrease of in-hospital mortality due to aortic aneurysms with increasing compliance of ACR imaging and interventions protocols.

## 3. What are the implications for research, policy, or practice?

If increasing ACR compliance reduces mortality due to aneurysms, more US hospitals may be persuaded to improve their facilities and operations for maximum ACR compliance.

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## Background

US National Institute of Health (NIH) defines aneurysm as a balloon-like bulge in an artery. The prevalence rate of aortic aneurysms was highest in North-East, South-East and South-West and lowest in Mid-Western and Western regions of USA according to NIH. Aneurysm becomes a mortality risk when it is about to rupture any time or already ruptured. There is a minimum size above which the rupture can occur. Older males of 60 to 74 years and having smoked ever are the risk of developing any one of the six types of aneurysms. Hospital contexts which can lead to death of patients are: incorrect diagnosis due to wrong imaging protocols and incorrect treatment due to wrong diagnosis or any of the several other hospital factors. American College of Radiologists (ACR) have developed guidelines for diagnostic imaging and treatment interventions which are applicable to aneurysms as well.<sup>1,2</sup> Patient safety is an important consideration especially when radionuclides are used for diagnostic imaging or treatments. Most studies have examined the consequences of surgical interventions of repair on mortality rate of aneurysm patients. However, no study has attempted to directly relate compliance with ACR guidelines by hospitals on the mortality rate of aneurysm patients. The intention of ACR in publishing guidelines is to improve patient outcomes with minimum risk of safety. Not complying with such guidelines may lead to serious consequences for the patients.

Hospitals vary in their resources and human capabilities. These include: type of hospital, location, funding, physical facilities, types of imaging equipment, human resources and their competencies, costs and prices, other logistics and management style. These determine how the resources and capabilities are deployed and to what extent the guidelines are complied with.

There are indications from certain reports of low compliance level of US hospitals with ACR guidelines on aneurysm imaging and treatment interventions. The data on patient outcomes in various US hospitals collected by Huber et al.<sup>3</sup> may suggest the possibility of low compliance levels. Examination of 204 aneurysm cases by XYZ<sup>4</sup> revealed the likelihood of low compliance levels on long term follow-up surveillance after surgical interventions.

In the findings of Lakhani et al.<sup>5</sup> increasing ACR compliance improved non-routine critical radiological communications in tertiary hospitals. Better outcomes by higher level of compliance by radiologists were also reported by Benjamin et al.<sup>6</sup> Gilk et al. noted good relationship between updated ACR guidelines on MR practices and the Joint Commission's Sentinel Event Alert No 39 on MR safety as the Environment of Care standards. About 90 per cent of US academy emergency departments deviated from the guidelines. Abramson et al.<sup>7</sup> noted wide variations in ACR compliance levels of different hospitals. Radiation exposure was reduced in some hospitals when they complied with ACR better.<sup>8</sup> Being awarded with certificates for better compliance with ACR guidelines in the websites of some hospitals.

From the above discussions, it can be hypothesised that compliance with ACR guidelines can improve imaging and diagnosis and reduce mortality of aneurysm patients with improved patient safety. Logically, increasing levels of compliance on imaging should increase these effects. Some questions arising here are-

1. Does the imaging method influence mortality during hospitalization among aortic aneurysm patients who underwent interventional repair?
2. If it does, could a different imaging method have been more suitable for better diagnosis and more appropriate intervention and thus reduce mortality?
3. Whatever be the imaging method used, did the hospital fully comply with ACR guidelines on imaging procedures?
4. Is there any relationship between compliance levels of hospitals with ACR guidelines with aneurysm mortality of aneurysm patients?
5. What is the role of various patient characteristics and hospital contexts on in-hospital mortality with respect to the relationship between imaging procedure adopted and interventional repair?
6. Does compliance guarantee significant reduction in in-hospital mortality rates? If so, how to determine the extent of compliance both in terms of items complied/not complied and extent of compliance?

This paper reports on a study aimed at finding out whether extent of compliance with imaging guidelines of ACR has any relationship with in-hospital mortality of aneurysm patients.

## Method

### Data collection

From NIS data sources, 47 US hospitals participated in the study. ACR appropriateness guidelines for aneurysm diagnostic imaging were used. Only Computed Tomography (CT), CTA (CT Angiography), Magnetic Resonance Imaging/Angiography (MRI/MRA), Digital Subtraction Angiography (DSA) and Ultra-Sound (US) were included as they are the most commonly used imaging methods for aneurysm diagnosis. The extent of use of all other imaging methods combined was very insignificant and hence, non-inclusion of other imaging methods will not materially affect the findings.

Data on six major types of aneurysms were used. The exclusion of the remaining aneurysm types would not have significantly affected the results as they were very rare cases.

Table 1 gives the ACR appropriateness guidelines and the rating scale for appropriateness levels. According to this rating scale, scores of 1, 2 and 3 indicate “Usually not appropriate” status and above the score up to 6 indicates “May be appropriate” and 7–9 score indicates “Usually appropriate” status. Even if all the guidelines are met, the rating is not “Appropriate” but a tentative “Usually appropriate”. Similarly, even if all the items are not complied with, the rating will be a soft “Usually not appropriate” rather than “Not appropriate”. This is a serious drawback of the rating. In this study, scores 1, 2 and 3 are combined as 1 to indicate “Usually not appropriate”, 4–6 as “May be appropriate” and 7–9 as “Usually appropriate” compliance levels. The difference between the ACR rating scale and the scale used in this work is explained in Table 2.

However, such ratings do not say anything about the seriousness of lapses in compliance levels. This may make it difficult to relate compliance level with in-hospital mortality.

### Data analysis

Using the data filtering method of NIS database for aneurysm, a sample size of 38,263 patient records were obtained for statistical analyses described above for the five-year period covering 2008–2012. After excluding samples which did not provide the required information, a

net sample size of 38,104 was available for analysis and reporting the results.

These data were analysed for Pearson’s Chi-Square test, Gamma Correlation test and Logistic Regression test using the latest version of SPSS software.

## Results

### ACR Compliant imaging methods and in-hospital aneurysm mortality

If compliance level is critical in determining mortality rate, use of imaging methods in strict compliance with ACR should reduce mortality substantially. However, there can be variations among imaging methods to produce this effect. This aspect was studied and the data are presented in Table 3.

CTA had very few number of patients reported and hence zero mortality obtained here is suspect. CT imaging of abdomen and pelvis as well as thoracic regions recorded similar mortality rate in the range of 10.5–12.0 per cent. The mortality rate was only 5.3 per cent for US and was the lowest 2.6 per cent for DSA. Based on length of stay, DSA was found undesirable in the earlier discussions. However, mortality rate itself is minimum for DSA and this may be associated with short period of hospital stay. All statistical tests were highly significant. Therefore, if ACR compliant procedures are used, DSA method is most effective followed by US in reducing mortality rate.

### Linearity of relationship of ACR compliance with predictors

Chi-Square tests gave highly significant Likelihood ratio and Linear-by-linear values. Thus the model fitted better with predictors and the relationship was strongly linear in the case of compliance on radiological procedures (Table 4). Thus, if there is increased ACR compliance with respect to radiological procedures, the in-hospital mortality is reduced.

### Relationship between ACR Compliance and in-hospital aneurysm mortality

Gamma test and other tests had relatively low negative value indicating negative relationship between ACR compliance and mortality. Gamma=-0.328, which also indicates a strong degree of inverse correlation. Thus, higher the compliance, lower is the mortality rate. As explained below, Tables 5 and 6 give this result more clearly.

### ACR Compliance rating and in-hospital mortality

As was explained in the Methods section, the rating scale

proposed by ACR was found inadequate and hence modified for this study. The effect of ACR compliance according to the modified rating scale is presented in Table 6.

There is progressive reduction in aneurysm mortality as the ACR compliance level increased from usually not appropriate to may be appropriate and further to usually appropriate. The percentage reductions were 5.3 per cent, 2.8 per cent and zero per cent respectively. The overall in-hospital mortality itself is reduced to zero when there is highest level of compliance to usually appropriate. This is clearer from Table 7, in which the direct effect has been presented. However, there is need to exercise caution in reaching this conclusion. Only four cases could be attributed to the highest compliance rating of usually appropriate. The zero mortality, in this case, may be suspect due to this limitation.

#### **ACR Compliance rating and in-house mortality relationship**

As is clear from Table 8, all the test values are highly significant. Hence there is strong linearity of the relationship between ACR rating scores and in-hospital mortality.

A predictive probabilistic equation for odds relationship of ACR compliance with mortality rate was attempted. The equation parameters are given in Table 9.

According to the parameters in Table 9, the odds relationship for ACR compliance with mortality rate is given by the equation-

$$\text{Ln (Odds)} = -1.472 - 0.676 * \text{ACR compliance rating}$$

As the equation will result in negative estimate, odds for mortality decrease when ACR compliance of hospitals increases. The Wald test value is significant indicating that there no interference of other predictors on the relationship. Also, the odds for mortality compared to not dying is even as the value of Exp (B) is only 0.508 although the value ranges from 0.334 to 0.775.

#### **Discussion**

Summarising the findings, if diagnostic imaging methods fully complying with ACR guidelines are used, DSA and US give lowest in-hospital mortality of aneurysm patients. Highly significant likelihood ratio, strong linearity and negative relationship between ACR compliance rating and mortality were observed when different imaging methods were considered. In the case of ACR compliance rating in relation to in-hospital mortality, progressive increase in compliance level from usually not appropriate to may be appropriate and finally to usually appropriate reduced in-

hospital mortality rate. The negative relationship between them was shown by negative values of both intercept and slope of the probabilistic equation constants. Overall, ACR compliance with respect to diagnostic imaging and interventions can reduce in-hospital mortality rates of aneurysm patients.

In the Background section, it was indicated that no direct evidence exists on the effect of complying with ACR guidelines in reducing in-hospital mortality of aneurysm patients. However, there are indications from certain findings on the possibility of poor compliance by US hospitals of ACR guidelines.<sup>3,4</sup> A few other findings<sup>5,6,8</sup> that compliance with ACR guidelines improved diagnosis and patient outcomes. One finding noted large variations among hospitals in complying with ACR guidelines.

Only in-hospital mortality was considered here. The patient may still die at any time out of the hospital. As the cases represent the hospitals, it can be deduced that a large majority of hospitals either comply very little with ACR guidelines at all (usually not appropriate) or sometimes /in some respects comply with the ACR guidelines. It could also mean that, in either group or both groups a few hospitals comply fully and others do not comply at all. This problem is because the rating based on patient mortality is an average effect of all the hospitals in each category and may not reflect compliance level per se. For the same reason, it is not possible to differentiate compliance levels for each aspect of the ACR guidelines. A more direct approach of surveying the hospitals for this purpose is essential to identify the problems in detail.

The objective of this study was to verify whether compliance with ACR guidelines will indeed reduce mortality. When fully compliant imaging procedures were evaluated for mortality, there was decisive decrease in mortality rates. This verified the contention of this objective. Usefulness of ACR compliant MRI for diagnosis of giant cell arteritis was demonstrated by Narvaez et al.<sup>9</sup> Compliance with ACR criteria for patients qualifying for any imaging procedure was found highly useful in comparing different imaging methods for different arthritis types in the studies by Pipitone et al.<sup>10</sup> In the case of coronary CTA, Miller et al.<sup>11</sup> found about 46 per cent of the CTA studies in their institution covered indications not covered by the ACR appropriateness criteria. Siström<sup>12</sup> supported ACR appropriateness guidelines and its conversion into online searchable form. This can be incorporated into clinical decision making systems of hospitals. This will enhance compliance. Methods used for development and review of

criteria for updating them are sound. Two action points emerge out of these results-

1. There are a large number of hospitals which are in the lower rating categories if total patients in the rating category are any indication. If these hospitals improve their compliance levels, mortality rate can be reduced substantially.
2. Now most patients are reporting in hospitals of low rating category. If they switch to higher rating categories, mortality rate can be reduced significantly.

The latest ACR imaging appropriateness criteria for pulsatile masse suspected to be AAA were discussed by Desjardins et al.<sup>13</sup> US is the initial imaging method when a pulsatile mass is to be confirmed as aneurysm. In the case of patients for whom US is unsuitable, non-contrast CT can be used. When aneurysm reaches the size required for intervention or is clinically symptomatic, contrast-enhanced multi-detector CT angiography (CTA) is best for diagnostic and pre-intervention planning assessment. CTA can accurately determine location, size, extent of aneurysm and branching vessels affected. If CTA cannot be performed, MRA can be substituted. Catheter angiography is useful for patients who show contraindications against both CTA and MRA. ACR reviews its guidelines every two years and updates its appropriateness criteria based on accruing evidence. These criteria show that different imaging methods are to be used for different situations. Although US can be substituted by CT, it cannot be substituted by other methods. CTA and MRA are to be used on special conditions depending on patient suitability only. There is no mention of DSA although catheter angiography can substitute CTA or MRA. Evidently, the imaging methods used for patients in this study were not according to these criteria as DSA was most frequently used method followed by US. If ACR guidelines were followed, it should have been US, CTA and MRA in the decreasing order of frequency. Overall, neither ACR guidelines cover all clinical indications nor hospitals comply with the basic criteria on which imaging method to be used and when. Studies on predictive factors for each imaging method may be useful. Some studies indicate that lower probability of mortality can be predicted for all age groups, CT can be used as the imaging method. If no comorbidities are diagnosed, MRI can be used. For all comorbidities, either US or DSA can be used. When hypertension, diabetes, respiratory disease or myocardial infarctions are indicated, CT can be used. Male gender was specified for CT and DSA. Probably cost considerations lead to preferential choice of DSA or US.

At a more practical level, progressive use of age group to which patient belongs, comorbidities, type of insurance for reimbursement as filters can lead to the choice of different imaging methods for different patient factors.

Not all hospitals may have all imaging facilities or expertise to do so. Hence, the clinician decides the imaging method depending on available facilities. It need not necessarily be the ideal imaging method as determined by the above-discussed aspects. Thus, chances of a hospital not complying with many items of appropriateness criteria for diagnostic imaging are high. This was reflected in a large number of patients being diagnosed in hospitals rated "usually not appropriate" or "may be appropriate" categories rather than in the "usually appropriate" category. There is no "definitely appropriate" category in ACR rating standards. So at present, most patients are diagnosed in hospitals which are less than perfect in complying with ACR imaging guidelines. This study has established good relationship between ACR compliance and mortality (Tables 5 and 6) and imaging method and mortality (Table 3).

However, as was seen in the report of Desjardins et al.<sup>13</sup> specific imaging methods are considered appropriate for specific situations by ACR. Certainly this is not complied with. Overall it appears, hospitals should increase their compliance with ACR appropriateness criteria for diagnostic imaging by adhering to imaging methods prescribed for each situation. Hospital contexts were not important determinants although most patients reported in urban teaching or non-teaching hospitals. This may be just the reflection of population distribution between urban and rural areas increasing the chances of aneurysm in areas of higher populations. Important patient factors are age and presence of comorbidities. Other patient factors like gender or race are not important. Similarly, among hospital contexts, admission or insurance types are also not very important. This means, hospitals need to focus only on the two factors of age and comorbidities to assign suitable imaging methods as per ACR. Both are known or found out at the initial stages of diagnosis itself. Thus, it is possible to use suitable imaging method for any patient without difficulty. One factor which has received little attention is a detailed survey and study on the physical and logistical facilities and expertise available in hospitals against ACR guidelines. This information needs to be used for calibrating diagnostic imaging methods.

#### **Strengths of this study**

Therefore, the first strength of this study is that it provides direct evidence on the beneficial effect of complying with

ACR guidelines in reducing in-hospital mortality of aneurysm patients.

A fairly large sample of 38,104 patients covering the recent five year-period of 2008–2012 increases the validity and generalizability of the conclusions obtained.

### **Study limitations**

The study relied on diagnosis and procedure of only the ICD-9 coding registered in NIS dataset. NIS data does not include all the sophisticated diagnostic imaging procedure codes. Differentiation of pre- and post- operative imaging is not available in ICD-9 codes and is not indicated in NIS data also. This study was limited to the study of most common aneurysms and not all.

As was indicated earlier, the relationship between ACR compliance rating and mortality rate was based on the total number of patients rather a comparison of hospitals per se. Only in-hospital mortality was considered. This does not preclude patients dying at any time after discharge from the hospital.

### **Implications for policy and practice**

There is clear indication that compliance with ACR guidelines will reduce aneurysm mortality. Therefore, the following policy and practice level actions are suggested based on the findings of this research.

A policy enforcing full compliance with ACR diagnostic imaging and treatment interventions may be useful to reduce in-hospital mortality due to aneurysm. At least diagnostic imaging procedure for simplest and cheapest imaging equipment like X-ray or ultrasound supported by ACR compliance should be made the minimum requirement at all US hospitals. In advanced hospitals, ACR-compliant facilities for more imaging methods can be implemented.

Most US hospitals are not complying with ACR imaging guidelines. They are encouraged to immediately start full compliance process. It can be done in stages starting from simplest imaging method to other imaging methods. This will solve resources problems at least to some extent. If definite policies on compliance are announced by the authorities, hospitals may be forced to undertake this.

### **Implications for future research**

More direct evidence will be survey of hospitals for ACR compliance estimation. This first attempt will need development of the full protocol for the survey and test its validity and then use it for actual survey. The survey results

can be classified into different levels of ACR compliance, number (and percentage) of hospitals in each category and the mortality rate for each category. Some qualitative elements of the easiest and the most difficult items of the guidelines for hospitals to practice can also be identified by using suitable items in the survey. Based on the results obtained, further actions can be started.

Poor compatibility of NIS data with ICD-9 was a serious problem in collecting all the required information. Use of ICD-10 to solve this problem can be explored.

Use of more patient cases spread over longer term (more than five years) covering more US hospitals will be an exhaustive work. This can be combined with the survey work said above. A large team of collaborating scientists will be required to undertake the task. But such a study is well-worth the effort.

Only in-hospital mortality was observed in this study. Patients may die any time after being released from hospitals. Although, it is not entirely controllable by hospitals, follow up case study on samples of patients discharged from the hospitals could be useful. If certain mortality risks after discharge could be avoided through some precautionary steps while they are in hospitals, this type of mortality could also be controlled.

### **Conclusion**

The findings of the study reported here demonstrate clear evidence of compliance with ACR guidelines reducing in-hospital mortality of aneurysm patients, even to zero mortality level. As the level of compliance increases, reduction in mortality also increases. Although suitable imaging method for each patient needs to be decided on the basis of age and comorbidities, once this is decided, the actual imaging procedure should be based on ACR guidelines. Policies to persuade full compliance with ACR guidelines need to be set by competent authorities. However, hospitals need not wait for such policies to be declared. They can start ACR compliance on their own. All hospitals may not have or require all types of imaging methods. Most primary hospitals can have one or two ACR-complied imaging method and more advanced hospitals in the area can have more imaging methods. Primary hospitals can refer their patients to the advanced hospitals for other imaging methods. This will save cost and other resources. These are the quickest ways of implanting the ACR compliance by all hospitals.

Future research on expanding this work to more patients, longer term data and more hospitals with a survey for a more direct assessment of ACR compliance and outcomes and identification of critical items of guidelines which are difficult to comply, need to done. The coverage of large area and voluminous data collected justify a large team study. Compatibility of NIS data with ICD-10 criteria and out of hospital mortality are some extensions of this study.

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## PEER REVIEW

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## CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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## ETHICS COMMITTEE APPROVAL

Ethics approval was not required.

**Table 1: ACR Appropriateness Diagnostic Imaging Criteria for Aneurysm Repair<sup>2</sup>**

Radiologic Procedure	Rating	Comments	RRL
CTA abdomen and pelvis with contrast	9	For evaluation of known AAA without thoracic aortic involvement. Non contrast sequence is not necessary for interventional planning.	⊕⊕⊕⊕⊕
CTA chest abdomen and pelvis with contrast	8	Useful for patients with suspected AAA but no prior workup thoracic aortic. Study of choice for workup of suprarenal AAA or thoracabdominal aneurysm	⊕⊕⊕⊕⊕
CT abdomen and pelvis without contrast	6	At physicians discretion chest may not be included. Appropriate for patients with contraindication iodinated contrast. Occasionally depicts density difference between the blood pool and aortic wall/mural thrombus. Otherwise further assessment with MRL, US or DSA would be preferred.	⊕⊕⊕⊕⊕
MRA abdomen and pelvis without and with contrast	6	Alternative to CTA in patients with known AAA not involving the thoracic aorta and in whom iodinated contrast is contraindicated. See statement regarding contrast in text under	0
CTA chest abdomen and pelvis without contrast	5	Appropriate for patients with contraindication to iodinated contrast. Occasionally depicts density difference between the blood pool and aortic wall/mural thrombus. Eitherwise further luminal assessment with. MRA US or DSA would be preferred.	⊕⊕⊕⊕⊕
Digital subtraction angiography{DSA}aorta	5	My be appropriate in select cases including patients who require pre-operative embolization of branch vessels or those requiring further characterization of the aortic human with an alternative contrast agent{such as co2} or intravascular US.	⊕⊕⊕
MRA chest abdomen pelvis without and with contrast	5	Alternative to CTA in patients with contraindication to iodinated contrast who have had no prior evaluation of thoracic aorta. See statement regarding contrast in under text". Anticipated exceptions"	0
MRA chest abdomen pelvis without contrast	4	Appropriate for patients with several renal dysfunction	0

Radiologic Procedure	Rating	Comments	RRL
MRA abdomen and pelvis without contrast	4	Appropriate for patients with several renal dysfunction. At physicians discretion chest may not be included	0
US aorta abdomen with doppler	3	Useful screening tool but insufficient for AAA treatment planning. May be used in tandem in USA in the absence of cross sectional imaging or as an adjunct to non-contrast CT for luminal evaluation.	0
X-ray chest abdomen pelvis	1		☼☼☼

**Table 2: Comparison of ACR rating scale with the scale adopted for this study**

ACR Rating Scale		The Study Rating Scale	
1,2,3	Usually not appropriate	1	Usually not appropriate
4,5,6	May be appropriate	2	May be appropriate
7,8,9	Usually appropriate	3	Usually appropriate

**Table 3: The Effect of Using Strictly and Fully ACR Compliant Radiological Methods on Frequencies of In-Hospital Mortality of Aortic Aneurysm Patients in USA**

ACR radiological procedures			Died during hospitalization		Total
			Did not die	Died	
CT☼A	Count	4	0	4	
	%	100.0%	0.0%	100.0%	
CT Abdomen & Pelvis	Count	199	27	226	
	%	88.1%	11.9%	100.0%	
CT Thoracic	Count	224	26	250	
	%	89.6%	10.4%	100.0%	
US	Count	4619	259	4878	
	%	94.7%	5.3%	100.0%	
DSA	Count	31881	865	32746	
	%	97.4%	2.6%	100.0%	
Total	Count	36927	1177	38104	
	% within ACR	96.9%	3.1%	100.0%	

**Table 4: Chi-Square Test Results on Effect of ACR Compliant Radiological Procedures on Frequency of In-Hospital Mortality among Aortic Aneurysm Patients in USA**

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	206.255 <sup>a</sup>	4	<0.001
Likelihood Ratio	152.579	4	<0.001
Linear-by-Linear Association	197.995	1	<0.001
N of Valid Cases	38104		

**Table 5: Gamma Test Results on Frequencies of In-Hospital Mortality of Aneurysm Patients as Affected by ACR Compliance Levels of Hospitals in USA**

Symmetric Measures					
		Value	Asymp. Std. Error <sup>a</sup>	Approx. T <sup>b</sup>	Approx. Sig.
Ordinal by Ordinal	Gamma	-0.328	0.032	-7.617	<0.001
No. of Valid Cases		38104			
a. Not assuming the null hypothesis.					
b. Using the asymptotic standard error assuming the null hypothesis.					

**Table 6: Effect of ACR Compliance Levels of Hospitals on Frequencies of In-Hospital Mortality of Aortic Aneurysm Patients in USA**

ACR Compliance Rating			Died during hospitalization		Total
			Did not die	Died	
	Usually not appropriate	Count	4619	259	4878
		% within ACR Compliance Rating	94.7%	5.3%	100.0%
		% within Died during hospitalization	12.5%	22.0%	12.8%
	May be appropriate	Count	32304	918	33222
		% within ACR Compliance Rating	97.2%	2.8%	100.0%
		% within Died during hospitalization	87.5%	78.0%	87.2%
	Usually appropriate	Count	4	0	4
		% within ACR Compliance Rating	100.0%	0.0%	100.0%
		% within Died during hospitalization	0.0%	0.0%	0.0%
Total		Count	36927	1177	38104
		% within ACR Compliance Rating	96.9%	3.1%	100.0%
		% within Died during hospitalization	100.0%	100.0%	100.0%

**Table 7: Mean Effects of Increasing Compliance with ACR Appropriateness Criteria on In-Hospital Mortality Rate of Aortic Aneurysm Patients in USA**

Compliance Level	In-Hospital Mortality Percentage
Usually not appropriate	5.3
May be appropriate	2.8
Usually appropriate	0

**Table8: Chi-Square Test Results on Effect of ACR Compliance Levels of Hospitals on Frequencies of In-Hospital Mortality of Aneurysm Patients in USA**

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	92.255 <sup>a</sup>	2	<0.001
Likelihood Ratio	78.896	2	<0.001
Linear-by-Linear Association	92.252	1	<0.001
N of Valid Cases	38104		

**Table 9: Parameters of Predictive Probabilistic Equation for Effect of ACR Compliance by Hospitals on Frequencies of In-Hospital Mortality of Aortic Aneurysm Patients in USA**

Variables in the Equation									
		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
Step 1 <sup>a</sup>	ACR compliance rating	-0.676	0.215	9.909	1	0.002	0.508	0.334	0.775
	Constant	-1.472	0.417	12.472	1	<0.001	0.229		

a. Variable(s) entered on step 1: ACR compliance rating.