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Does biplane imaging reduce contrast load, procedural and screening time compared to single-plane imaging in routine diagnostic coronary angiography?

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Abstract Diagnostic coronary angiography requires radiographic contrast media that can cause complications such as contrast-induced nephropathy (CIN). Biplane imaging in diagnostic coronary angiography has been assumed to be beneficial to the patient in reducing total radiographic contrast dosage and examination time, yet there are no definitive studies to support this widely held assumption. A retrospective study was conducted to determine if biplane imaging substantially reduces contrast load, procedural time and screening time in routine diagnostic coronary angiography. Radiographic records of 1156 patients were collected over a period of two years from a major Sydney metropolitan hospital. Patients who underwent a routine diagnostic coronary angiogram and left ventriculogram (LV) were selected on predetermined criteria. The mean total contrast volume showed a small but significant reduction with biplane versus single-plane imaging (117.5 mL v. 124.3mL, $P < 0.001$). There was a small but significant increase in table time with biplane compared to single-plane imaging (47.3 min *v*. 45.2 min, $P > 0.024$). Similarly, a small but significant prolongation in screening time was found with biplane compared to single-plane imaging (4.8 min *v*. 4.2 min, $P < 0.003$). The mean number of cine angiography runs was 13.6 in biplane and 9.5 in single-plane ($P < 0.001$).

These results contradict the assumption that biplane cine angiography substantially reduces contrast load, procedural and screening time when compared to single-plane imaging.

Keywords: biplane, contrast induced nephropathy, contrast media, coronary angiography, single-plane

Introduction

Diagnostic coronary angiography utilises radiographic contrast media to delineate epicardial coronary lesions and assess left ventricular function. While contrast media is essential for the radiographic visualisation of coronary vessels, there are certain risks and complications associated with its use. One such complication is contrast-induced nephropathy (CIN). CIN is a life-threatening dose-dependent reaction and is commonly defined as a decrease in renal function 24–48 hours after contrast media administration, with a rise in serum creatinine levels of more than 25% from the baseline (or an absolute increase greater than 0.5 mg/dL) three to five days after the procedure.[1–9]

Preventative measures for CIN in cardiovascular procedures include pre-hydration, prophylactic administration of N-acetylcysteine and utilisation of iso-osmolar/hypo-osmolar contrast media. However, reducing the volume of contrast media within the procedure was found to be the most effective.[10–14]

Cigarroa, *et al*.[15] and Freeman, *et al*.[16] both investigated the significance of an adjusted volume of contrast media to patient's body weight and serum creatinine level (maximum radiographic contrast dose (MRCD)) in relation to the occurrence of CIN. CIN developed in 2% of cases when the calculated MRCD for a group of patients was not exceeded, and a 15-fold increase in incidence for a group where MRCD was exceeded. Similarly Rihal, *et al*.[12] reported a 12% increase in the risk of nephropathy with each 100 mL administered to the patient. As CIN has been found to be the third leading cause of acute renal failure in patients (10% of all admitted cases), it is essential that contrast load is kept to a minimum in any examinations requiring contrast media.[3,17]

Coronary angiography can be performed using either single-plane or biplane imaging equipment. Single-plane imaging involves the use of one x-ray tube to acquire images at different angles and requires a separate injection of contrast for each cine angiography run. Biplane imaging utilises two x-ray tubes and is capable of acquiring two simultaneous projections with a single contrast injection. Therefore, it is assumed that contrast load will not only be reduced, but screening time and overall procedural time will be shorter.

In biplane imaging, the screening time is inclusive of the total fluoroscopy and cine angiography time for both planes. The screening time should therefore be shorter for biplane imaging than single-plane imaging as it acquires two images simultaneously. Additionally, as the setup of the two C-arms require less movement throughout the procedure, the use of biplane equipment would accordingly assist in reducing procedural time when compared to single-plane imaging. Furthermore, because the runs are calculated from each individual plane, biplane should result in a slightly greater number of cine angiography runs than single-plane imaging. Where single-plane will complete the nine standard projections, biplane will produce ten projections due to

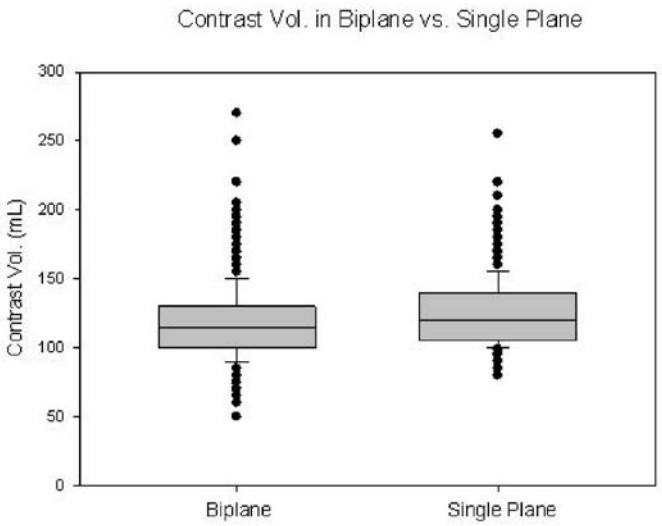

Fig. 1. Comparison of contrast volume in patients in biplane and single-plane. The mean contrast volume in single-plane was 124.29mL compared with 117.50mL in biplane imaging (P <0.001).

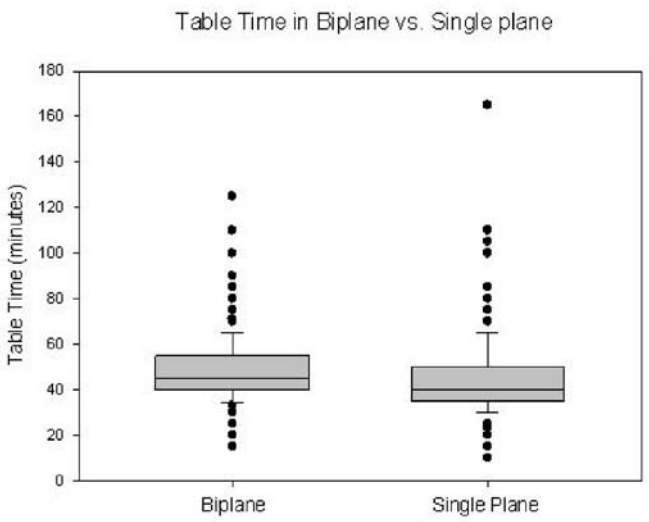

Fig. 2. Comparison of table time in biplane and single-plane. Mean table time for biplane was 47.31 mins and 45.20 mins for single-plane imaging (P <0.024).

the nature of the equipment

Bashore, *et al.*[18] and John Muir Health[19] along with others have subsequently assumed that biplane is beneficial to the patient in terms of reducing total radiographic contrast dosage and therefore its use may decrease the risk of CIN in patients.[20–31] However, since the concept of biplane imaging was introduced by Rob and Steinberg[32] in 1939 there have been no published data comparing the total contrast load used in single and biplane imaging in patients undergoing diagnostic coronary angiography.

The aim of this study was to test the hypothesis that biplane imaging in routine diagnostic coronary angiography results in a significant reduction in screening time, procedural time and contrast load within the procedure when compared to single-plane imaging. Additionally the study investigated whether bipolar imaging acquired a greater number of cine angiography runs compared to single-plane imaging.

Method

A retrospective study was conducted using the radiographic records of 1156 patients (biplane: 855 patients, single-plane: 301 patients) who underwent a diagnostic coronary angiogram and left ventriculogram (LV) at a major Sydney metropolitan teaching hospital.

Ethics approval was granted by the Human Research Ethics Committee (HREC) at the University of Sydney. Permission to conduct the study was then given by the Head of Cardiology at the hospital where the study was carried out.

The radiographic procedural records were collected from two cardiac catheterisation laboratories in the chosen hospital, which utilised the Siemens Axiom Artis dBC (biplane) flat panel detector system. The procedural records from June 2005 to June 2007 that met predetermined inclusion criteria were selected.

Patients who underwent a routine diagnostic coronary angiogram (including LV) with the nine standard diagnostic angiogram projections and who required the standard three angiographic catheters, 6FJL4, 6FJR4 and 6F Pigtail catheters were included in the study. The nine standard diagnostic angiogram projections include the left anterior descending (LAD) left anterior oblique (LAO), LAD right anterior oblique (RAO), LAD RAO craniocaudal, left circumflex (LCX) LAO, LCX RAO, LCX LAO caudal-cranial, left main anteroposterior (AP), right coronary (RCA) LAO and RCA RAO.

Patients who required more than the three standard catheter changes due to technical reasons or those who required interventional procedures such as balloon angioplasty, stenting or visualisation of bypass grafts were excluded. It was reasoned that these procedures would necessitate more than the standard number of coronary injections for diagnostic studies and thus increase the overall patient contrast load.

The following data obtained from the radiographic records for each patient were documented.

1 Total contrast volume: the sum of contrast used in the coronary angiograms and LV;
2 Screening time: the fluoroscopy time for catheter manipulation combined with the cine angiography time for the standard routine projections and LV;
3 Table time (procedural time): recorded from the time the patient was transferred onto the angiography table to the time the patient was removed from the table. The time included the set-up of the ECG monitors, pulse oximetry systems and preparation of the patient, including groin preparation and draping; and
4 Cine angiography runs: the number of cine runs recorded from each x-ray tube for the study.

The senior radiographer in the Cardiac Catheter Laboratory removed all patient identification details and the proceduralist‘s name prior to data collection and analysis. The procedural records were then coded and presented to the researchers in an anonymous format where confidentiality and patient identification were protected. Any missing data on the radiographic records were followed up on the hospital‘s computer system by the Senior Radiographer. Cases where data was neither available on the procedural records nor the computer system were omitted from the study. A Levene‘s Test of Equality and an Independent Sample‘s T-test was performed on the data collected using a P value <0.02 for statistical significance.

Results

Of the initial 1280 data sheets, 124 patients were excluded as the data relevant to this study was not recorded on the procedural

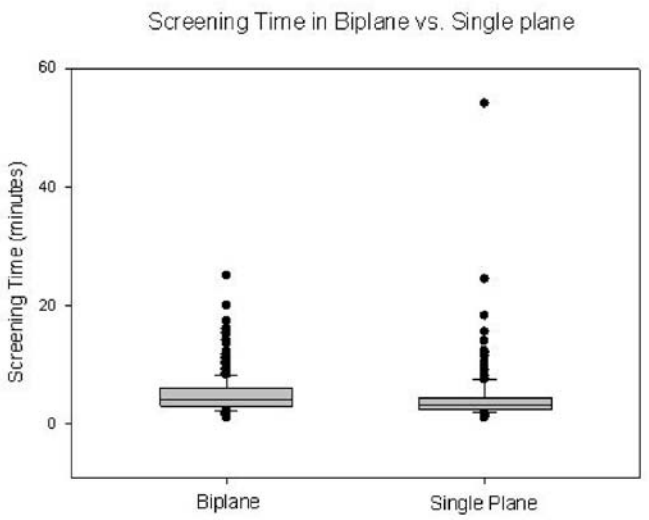

Fig. 3. Comparison of screening time in biplane and single-plane. Mean screening time of biplane was 4.81 mins and 4.22 mins in single-plane imaging (P <0.003).

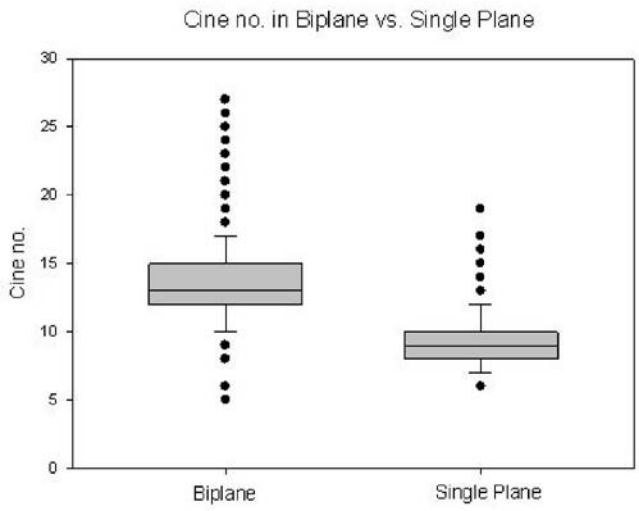

Fig. 4. Comparison of cineangiography runs (cine no.) in biplane and single-plane. The mean number of cineangiography runs for biplane was 13.59 and 9.45 in single plane imaging (P <0.001).

records or computer systems. Of the remaining 1156 patients, 301 had undergone single-plane imaging and 855 had undergone biplane imaging. As patient identification was removed, the age and sex of the patient were not included in the data collection.

Analysis of data by an Independent Samples T-test indicated a significant difference between the distributions of contrast volume, screening time, and cine angiography runs within the two groups (biplane and single-plane). The total contrast volume collected from 1156 procedural records, demonstrated that the mean contrast load used in biplane imaging was lower than that of single-plane (117.5 mL *v.* 124.3 mL, P <0.001). Fig. 1 represents the distribution of contrast volume in both imaging techniques. Conversely, mean fluoroscopy time (4.8 min *v.* 4.2 min, P <0.003), mean table time (47.3 min *v.* 45.2 min, P >0.024) and mean cine angiography runs (13.59 *v.* 9.45 P <0.001) was higher for biplane compared to single-plane respectively (Figs. 2–4). Table time however, did not show statistical significance between biplane and single-plane (P >0.024).

Discussion

In the hospital where this study was conducted, an average sized patient for routine coronary angiograms would receive up to 10 mL of contrast media for each cine angiography run and 45 mL for the LV. Given that biplane obtains two simultaneous projections with one injection of contrast media, five injections would generally be required as opposed to nine injections with single-plane imaging. Theoretically, a coronary angiogram and LV performed within this hospital with single-plane imaging would utilise a total contrast volume of 135 mL, while on average, biplane would use 85 mL – 63% of the contrast load of single-plane. Accordingly, the total contrast load delivered to the patient in biplane imaging should be slightly more than half the amount given by single-plane systems.

The study established a mean contrast load of 117.5 mL for biplane imaging, 94% of the total volume of contrast media utilised in single-plane imaging (mean of 124.3 mL). Although the difference was statistically significant (P <0.001), it was however much less than expected.

With biplane imaging utilising an average four more cine angiography runs than single-plane, the number of cine angiography runs was the only variable that agreed with the initial assumption that a slightly greater number of runs are performed in biplane compared to single-plane imaging. Biplane imaging generates a RAO and LAO cine angiography run for the LV, while single-plane only acquires the LV in the RAO projection. Furthermore, from observation by researchers throughout the study, the operator may not turn off one imaging plane when performing the final run of the nine standard projections and thus carry out an unnecessary cine angiography run.

The additional 0.6 min of screening time for biplane imaging may be explained by the more complex positioning and set-up required for each projection. Biplane equipment involves intricate adjustments in table height, as well as alignment of the two respective planes to position the area of interest within the iso-centre of both imaging tubes. Furthermore, due to limitations in the proximity of the two C-arms and the angiographic table, it may not be possible to optimally demonstrate the vessels of interest in each projection for each respective plane. If repeat cine angiography runs are required to obtain diagnostic images in each respective plane of biplane imaging, this may help clarify the longer screening time, table time and the use of a larger than expected contrast load found in this study with biplane imaging.

Cardiologists who elected to use single-plane equipment found they could manoeuvre the single C-arm more efficiently and have greater control in limiting the volume of contrast media delivered (personal communication, anonymous 2007). They also appeared to be more conscious of the contrast media load than operators of biplane equipment. Additionally, biplane operators may have a greater appreciation for a simultaneous visualisation of both planes of imaging and thus be less inclined to consciously monitor and limit contrast media dosage. Some may also assume that biplane imaging already reduces contrast load in comparison to single-plane equipment. This may have potentially biased the results and partly be responsible for the findings in this study.

Alternatively, as the data was collected from a single large teaching hospital, the rotation of advanced trainees could have had an effect on the results collected over the two-year period. Unfamiliarity of biplane equipment will increase the amount of time taken to set-up the imaging tubes and manoeuvre the equipment during the procedure. Suboptimal images will require

repeated images, thus increasing contrast load, number of cine angiography runs and procedural time.

The results from the data collected raise concerns as it is generally assumed that biplane is beneficial to the patient in terms of reducing total radiographic contrast dosage.[18–31] A publication released by Siemens Medical[33] in 2004 evaluating the clinical experiences with the AXIOM Artis BC biplane flat panel detector system stated that ,the doses of contrast medium and radiation exposure are drastically reduced and the examination is greatly shortened. The findings in this study do not support the statement by Siemens Medical and may highlight a greater risk to patient safety with the utilisation of biplane equipment than previously assumed, particularly as its use is recommended in paediatric and adult catheter laboratories.[25,30,33]

The mean contrast load for coronary angiograms performed in this study was found to be greater than 100 mL for both single and biplane imaging. Concerns are raised when these results are evaluated with other contrast media studies including Rihal, *et al*.[12] and Freeman, *et al*.[16] For diagnostic studies, Mehran, *et al*.[34] recommended a total contrast dose of <30 mL. These recommendations on the volume of contrast media can be difficult to adhere too as coronary angiography procedures are strongly operator dependent. The cardiologist may choose to use either single-plane or biplane, they may acquire repeat injections at the discretion of the operator, patients' anatomy may be complex, or there may be difficulties in catheter access. Therefore, this study allows cardiologists to be in a position of having a better understanding of the potential risks involved with biplane and single-plane imaging and assist the cardiologist in selecting the most appropriate imaging technique. This will ultimately result in lower morbidity rates among patients undergoing coronary angiography.

Limitations

The majority of studies that analyse the volume of contrast media utilised in diagnostic/interventional cardiology procedures focus on the benefits and the necessity of utilising biplane imaging. These studies conclude that a 'three-dimensional projection' allows for a greater appreciation of the pathology of interest and a more accurate assessment of LV volumes and ejection fractions.[35] This study analysed some advantages and disadvantages of biplane and single-plane imaging in regards to contrast volume, screening time and table time. However, there are limitations that must be considered to determine the validity of the results. This study was retrospective in nature and there was no randomisation of patients or physicians performing the study. The actual recording of contrast load, screening time, table time and cine angiography runs was not monitored by the researchers. Therefore, this study depends on the assumption that information on the patient's radiographic records was accurately recorded for all cases.

There was no information on whether any test injections were performed before the cineangiograms were obtained. This would correspondingly contribute to the total recorded contrast load. Moreover, this study excluded patients with complex anatomy such as the presence of tortuous vessels and bypass grafts. Such patients are often more challenging for cardiologists and would require longer fluoroscopy imaging, subsequently increasing contrast load. Finally, these results cannot be generalised across all cardiac catheter laboratories.

Conclusion

The data collected have shown that the results contradict the common assumption that biplane cine angiography substantially reduces contrast load, procedural time and screening time. As such, the results of this study have demonstrated that biplane equipment is not being utilised to its full capacity and there are significant implications in routine coronary angiography procedures. Although the data obtained in this study could be significantly improved by overcoming the various limitations, the results are still valid and reliable enough to draw accurate conclusions. In light of such findings, promoting awareness of these results to operators and implementing greater training in the proper use of biplane imaging may result in a greater reduction in contrast load among patients undergoing coronary angiograms. Further prospective randomised controlled studies need to be performed in patients who undergo interventional cardiology procedures and in patients with renal failure and heart failure in order to determine whether biplane imaging can fulfil its expectations of reducing contrast load and shortening screening and examination time.

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References

1 Asif A, Epstein D, Epstein M. Dopamine-1 receptor agonist: Renal effects and its potential role in the management of radiocontrast-induced nephropathy. *J Clin Pharmacol* 2004; 44: 1342–51.

2 Asif A, Epstein M. Prevention of radiocontrast-induced nephropathy. *Am J Kidney Dis* 2004; 44: 12–24.

3 Briguori C, Colombo A, Violante A, Balestrieri P, Manganelli F, Elia P, *et al*. Standard v. double dose of N-acetylcysteine to prevent contrast agent associated nephrotoxicity. *Eur Heart J* 2003; 25: 206–11.

4 Gami A, Garovic V. Contrast nephropathy after coronary angiography. *Mayo Clin Proc* 2004; 79: 211–19.

5 Khawaja A, Zafir H, Gradman A. Reducing radiocontrast use in the cardiac catheterization laboratory – A behavioural modification approach. *Q Manage Heal Care* 2004; 13: 188–92.

6 King T, Sole M. Preventing renal complications from the use of contrast agents. *Am J Nurs* 2005; 105: 72AA–72EE.

7 Meschi M, Detrenis S, Musini S, Strada E, Savazzi G. Facts and fallacies concerning the prevention of contrast medium induced nephropathy. *Crit Care Med* 2006; 34: 2060–8.

8 Mueller C, Buerkle G. Preventing renal complications from the use of contrast agents. *Arch Intern Med* 2002; 162: 329–36.

9 Schrader R. Contrast material-induced renal failure: An overview. *J Intervention Cardiol* 2005; 18: 417–23.

10 Diaz-Sandoval LJ, Kosowsky BD, Losordo DW. Acetylcysteine to prevent angiography-related renal tissue injury. *Am J Cardiol* 2002; 89: 356–8.

11 Kay J, Chow WH, Chan TM, Lo SK, Kwoh OH, Yip A, *et al*. Acetylcysteine for prevention of acute deterioration of renal function following elective coronary angiography and intervention: A randomized controlled trial. *J Am Med Assoc* 2003; 289: 553–8.

12 Rihal CS, Textor SC, Grill DE, Berger PS, Ting HH, Best PJ, *et al*. Incidence and prognostic importance of acute renal failure after percutaneous coronary intervention. *Circulation* 2002; 105: 2259.

13 Shye KG, Cheng JJ, Kuan P. Acetylcysteine protects against acute renal damage in patients with abnormal renal function undergoing a coronary procedure. *J Am Coll Cardiol* 2002; 40: 1383–8.

14 Hodges MC, Rollefson WA. Comparison of low-volume versus standard-volume left ventriculography. *Catheter Cadiovasc Interv* 2001; 52: 314–9.

15 Cigarroa RG, Lange RA, Williams RH, Hills LD. Dosing of contrast material to prevent contrast nephropathy in patients with renal disease. *Am J Med* 1989; 86: 649–51.

16 Freeman RF, Donnel M, Share D, Meengs WL, Kline-Rogers E, Clark VL, *et al*. Nephropathy requiring dialysis after percutaneous coronary intervention

and the critical role of an adjusted contrast dose. *Am J Cardiol* 2002; 90: 1068–73.

17 Birck R, Krzossok S, Markowetz F, Schnulle P, van der Woude FJ, Braun C. Acetylcysteine for prevention of contrast nephropathy: Meta-analysis. *Lancet* 2003; 362: 598–603.

18 Bashore TM, Bates ER, Berger PB, Clark DA, Cusma JT, Dehmer GJ, *et al*. American College of Cardiology/Society for Cardiac Angiography and Interventions Clinical Expert Consensus document on Cardiac Catheterisation Laboratory Standards. *J Am Col Cardiol* 2001 37: 2170–214.

19 John Muir Health. John Muir Health: A guide to women's health; 2006. Available online at: www.johnmuirhealth.com/downloads/WH/WH_Spring_2006.pdf [verified October 2007].

20 Allen HD, Gutgesell HP, Clark EB, Driscoll D. Moss & Adams' Heart disease in infants, children and adolescents: Including the fetus and young adults 6th Ed. USA: Lippincott Williams & Wilkins; 2001.

21 Baim DS. Grossman's cardiac catheterization, angiography and intervention. 7th Ed. USA: Lippincott Williams & Wilkins; 2006.

22 Burger IM, Murphy KJ, Jordan LC, Tamargo RJ, Gailloud P. Safety of cerebral digital subtraction angiography in children. Stroke: Journal of the American Heart Association. *Pediatr Neurol* 2006; 37: 2535–9.

23 Heintzen PH, Bursch JH. Progress in digital angiocardiography. Netherlands: Kluwer; 1988.

24 Hijazi ZM. Interventions with AXIOM: Clinical experiences with AXIOM Artis and AXIOM Sensis in pediatric cardiology; 2004 Available online at: www.cardiology.usa.siemens.com/documents/pdf/case_axiomartis_bc_e_pediatric.pdf?name=Interventions+with+AXIOM+Clinical+experiences+with+AXIOM+Artis [verified October 2007].

25 Maher KO, Norwood WI. Right ventricle to pulmonary artery shunt vs. Blahlock-Taussig shunt for the Norwood procedure. *Pediatr Cardiol Today* 2004; 2: 1–11.

26 Providence Medical Centre. Providence first in Kansas city and third in country to use twin digital; 2007. Available online at: www.providence-health.org/pmkckscms/about/news/2007/Providence+ First+in+Kansas+City+and+Third+in+Country+To+Use+Twin+Digital.htm [verified March 2008].

27 Schweiger MJ, Chambers CE, Davidson CJ, Zhang S, Blankenship J, Bhalla, *et al*. Prevention of contrast induced nephropathy: Recommendations for the high risk patient undergoing cardiovascular procedures. *Cath Cardiovasc Interv* 2006; 68:1–6.

28 Southwest Washington Medical Center. Southwest Washington Medical Center: Health Scene; 2005. Available online at: www.swmedctr.com/documents/Community%20Newsletter/FINAL07_05.pdf [verified October 2007].

29 Sterner G, Nyman U, Valdes T. Low risk of contrast-medium-induced nephropathy with modern angiographic technique. *J Intern Med* 2001; 250: 429–34.

30 Toshiba Medical Systems; 2007. Available online at: www.toshiba.co.jp/tech/review/1999/high99/h9903.pdf [verified 2007 Oct 12].

31 Verhoeven L, Mast EG. Coronary x-ray angiography: 40 Years of experience, Medicamundi; 1999. Available online at: www.medical.philips.com/main/news/assets/docs/medicamundi/mm_vol43_no2/mm_vol43_no2_article_coronary_xray_angiography.pdf [verified 2007 Oct 12].

32 Robb GP, Steinberg I. Visualization of the chambers of the heart, the pulmonary circulation, and the great blood vessels in man: A practical method. Am *J Roentgenol Radium Therap* 1939; 41: 1–17.

33 Siemen's Medical. Interventions with AXIOM: Clinical experience with AXIOM Artis and AXIOM senses in pediatric radiology; 2004. Available online at: www.medical.siemens.com [verified October 2007].

34 Mehran R, Aymong ED, Nikolsky E Lasic Z, Iakovou I, Fahy M, *et al.* A simple risk score for prediction of contrast-induced nephropathy after percutaneous coronary intervention: Development and initial validation. *J Am Coll Cardiol* 2004; 44: 254–61.

35 Bagshaw S, and Ghali W. Theophylline for prevention of contrast-induced nephropathy. *Arch Intern Med* 2005; 165: 1087–93.