# RESULTS

This study was carried out on 35 potential living kidney donors, their age distribution ranged from 24 years to 54 years (mean age 39 years). They were 16 men and 19 women. table (1) & Fig. (4).

Table (1): Age and Sex distribution among the studied 35 donors.

Age group	Number	%	Sex			
			Male	%	female	%
> 20-30 Y	6	17%	4	12%	2	5%
> 30-40 Y	22	63%	6	17%	16	46%
> 40-50 Y	5	15%	4	12%	1	3%
> 50-60 Y	2	5%	2	5%	0	-
Total	35	100%	16	46%	19	54%

In IV-DSA, we started with one view (antero-posterior) and this view was done in 4 cases, and 2 views (antero-posterior and oblique) were done in 19 cases, while 3 views (antero-posterior and two obliques) were required in 12 cases. This amount of C.M given to the donors varied according to the number of views required in each case (40 cc in each view) Table (2) & Fig.(5).

**Fig.(4): Age and sex distribution among the studied 35 donors.**
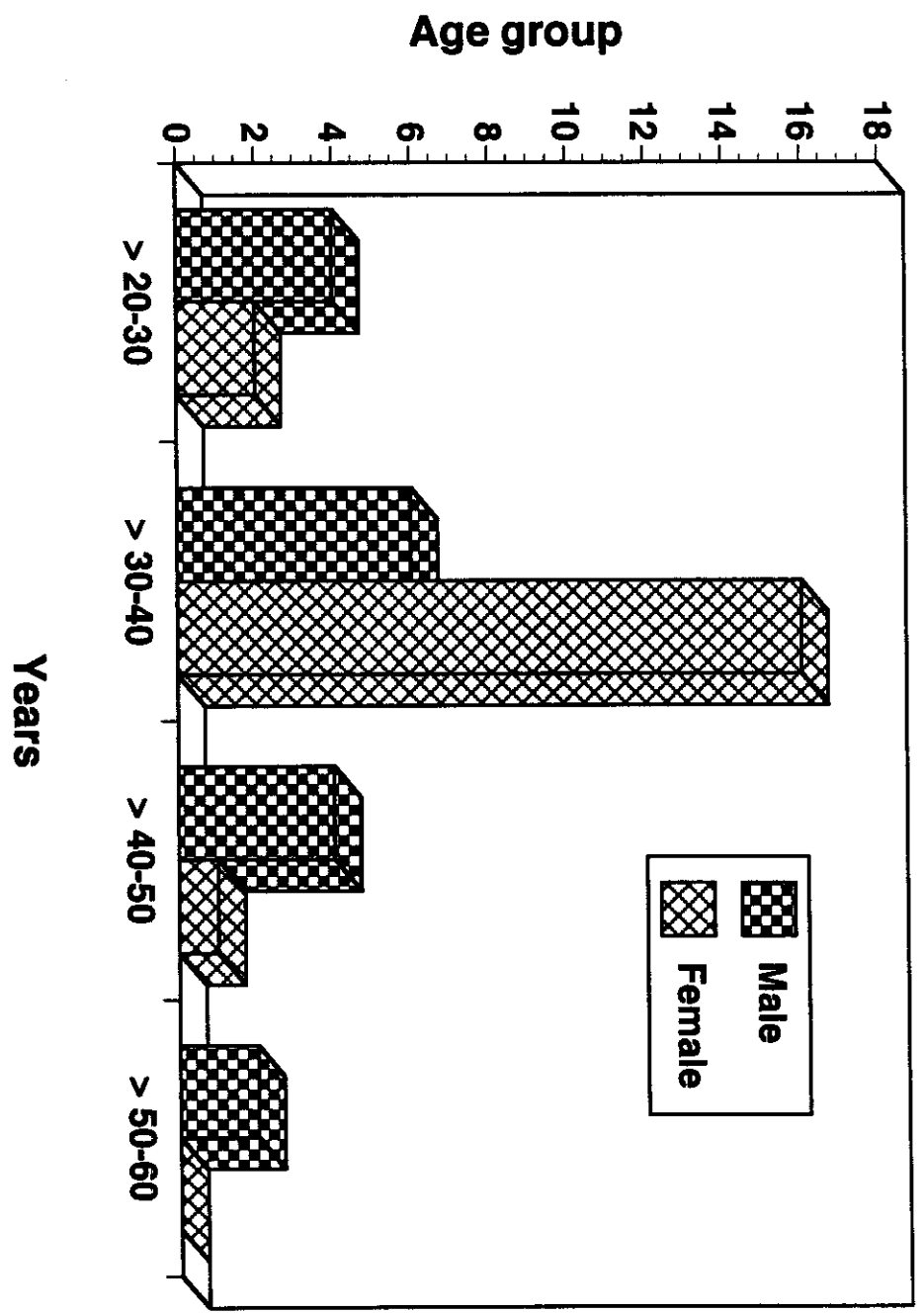
Table (2): Number of views and amount of C.M required in IV-DSA.

Number of views	Amount of C.M	Number of donors	%
One view (antero-posterior)	40cc	4	11%
Two views (antero-posterior and oblique)	80 cc	19	55%
Three views (antero-posterior and two obliques)	120 cc	12	34%
Total	--	35	100%

In IV-DSA the donors were exposed to X-Ray radiation (vary according to the number of views). 2 cases developed local swelling at the puncture site due to extravasation of C.M (5%), another 4 cases developed minor allergic reactions in the form of redness of the skin and vomiting (10%), these complications were managed conservatively.

By the use of IV-DSA the number, and localization of the renal arteries were detected accurately in 27 cases (77%) (confirmed surgically), while the remaining 7 cases (20%) were inaccurate (suspecion of accessory vessels, overlapping of lumbar arteries and inability to detect the origin of the renal artery from the aorta). Among these 28 cases 23 had single renal artery, 5 had double renal arteries . The remaining 7 cases were (at surgery) found to have single renal artery in 1 case, double renal arteries in 5 cases and triple renal arteries in 1 case.

Fig. (5): Number of views and amount of C.M required in IV-DSA.
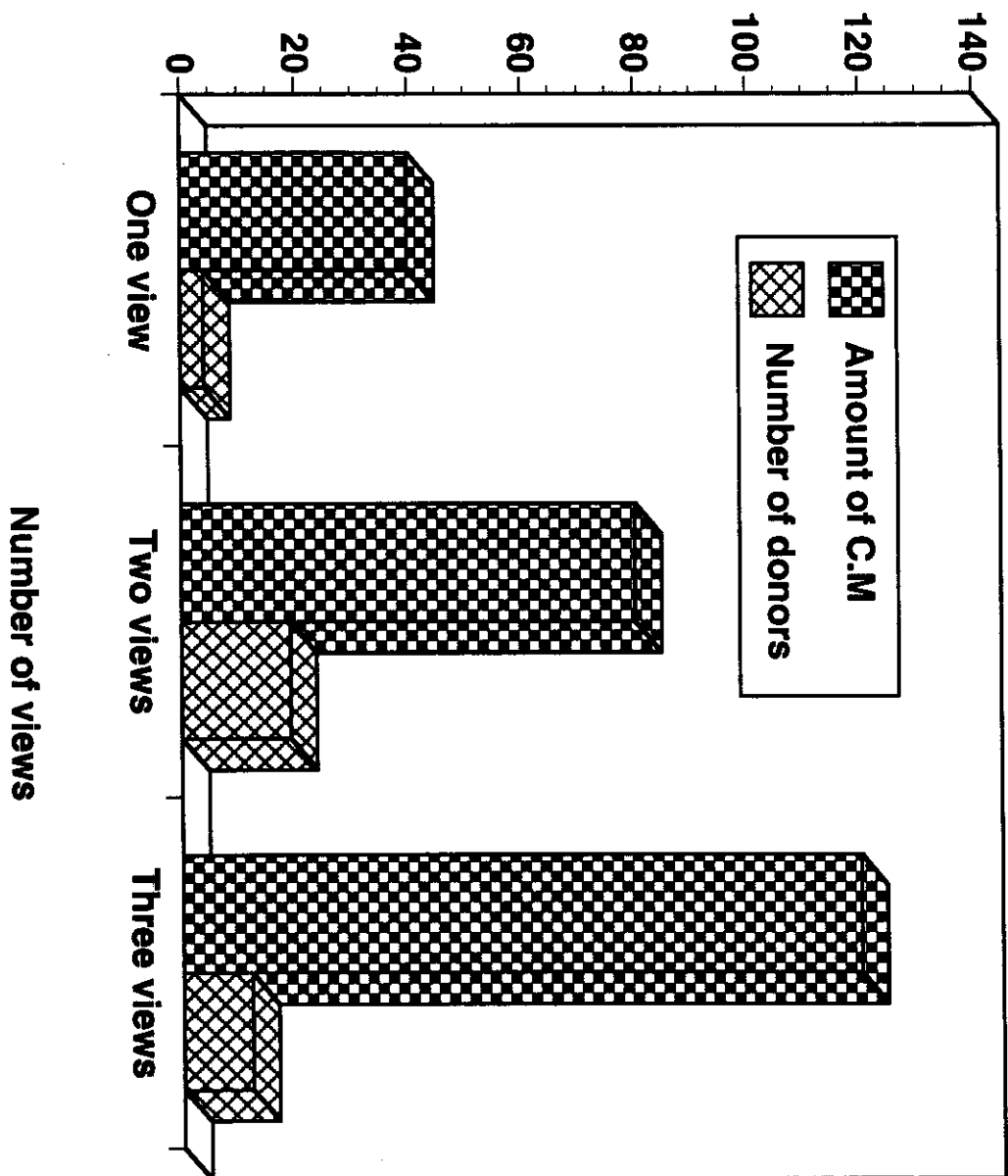
In IA-DSA, we started with one view (antero-posterior) and this view was done for 12 cases, 2 views (antero-posterior and oblique) were required for 18 cases and 3 views (antero-posterior and two obliques) were done for 5 cases.

The indications for additional views can be summarized as follow:-

1- Overlapping of small accessory renal arteries with lumbar arteries or visceral branches from the superior mesentric artery (16 cases)

2- Improper perparation of the donors and lack of cooperation with associated movement and poor breath holding as well as bowel motion gave unsatisfactory results and needed additional oblique views (5 cases).

3- In doubtful cases, to detect the origin of renal artery from the aorta and to determine the number of renal arteries, whether one artery with very early branching and short stem or double separate arteries with very closed ostea (2 cases).

The amount of C.M given to the donors varied according to the number of views required in each case (40 cc in each view and an addittional 20 cc C.M was given to each case for selective renal angiography [Table (3) & Fig. (6)].

Table (3): Number of views and amount of C.M required in IA-DSA .

Number of views	Amount of C.M	Number of donors	%
One view (antero-posterior)	60 cc	12	34%
Two views (antero-posterior and oblique)	100 cc	18	51%
Three views (antero-posterior and two obliques)	140 cc	5	15%
Total	--	35	100%

During IA-DSA the 35 donors were exposed to varying degree of X.Ray, 10 cases developed local haematoma at the puncture site (29%) and were managed conservatively, another 6 cases developed minor reactions after the automatic injection of C.M (17%).

In MRangiography the amount of C.M given to the donors was proportional to their body weight i.e. avarage dose was 0.5 m mol/kg body weight. In our study, 26 donors were given 30 ml Gd-DTPA each (74%), 6 donors each one of them was given 40 ml (17%), while the remaining 3 donors were given 50 ml for each of them (9%), [Table (4), Fig.(7)].

Fig. (6): Number of views and amount of C.M required in IA-DSA.
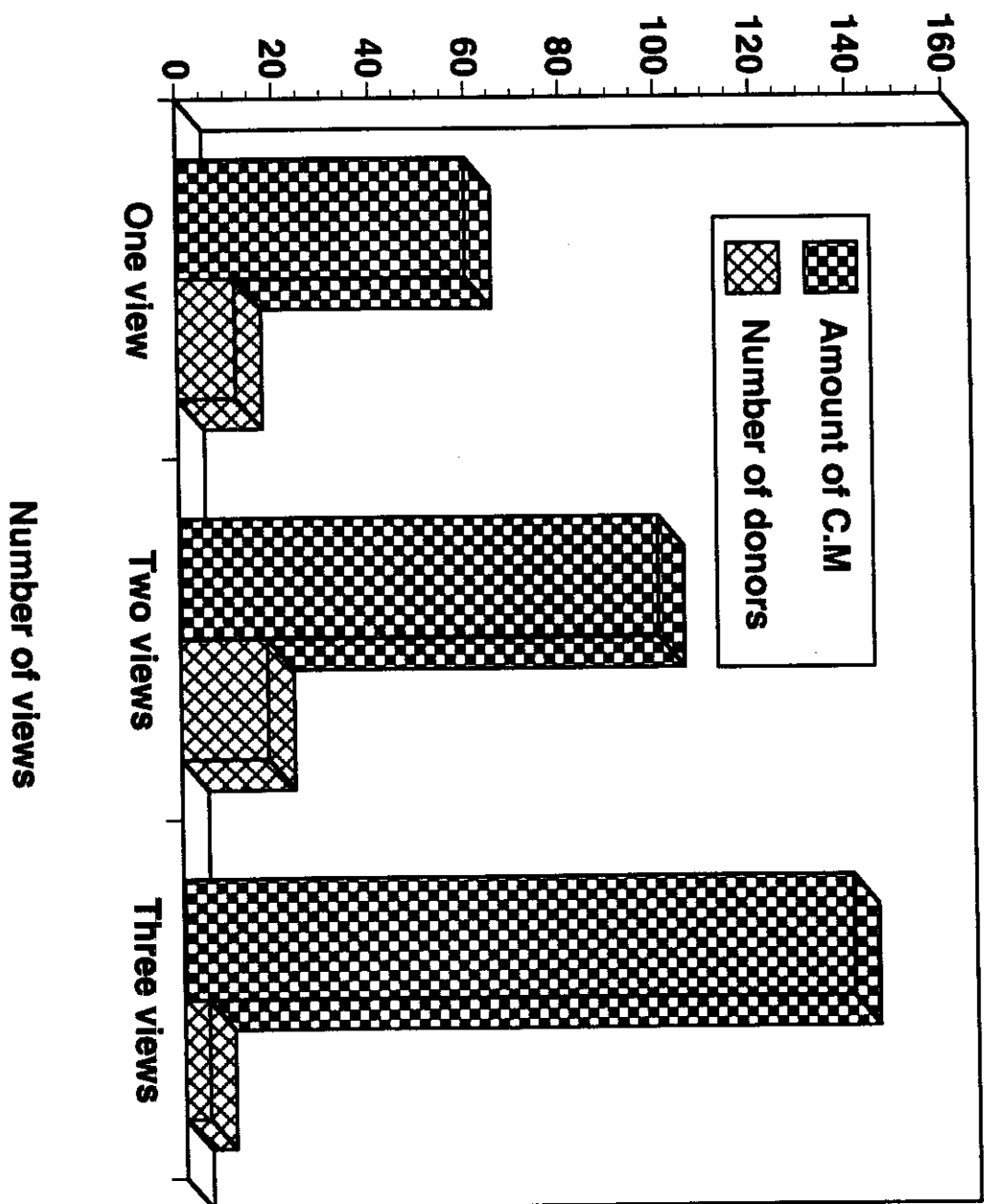
Three cases developed minimal local extravasation, they were managed conservatively, no recognised systemic allergic manifestations or major serious complications following the adminstration of C.M.

After the post-processing of MRangiographic images i.e. Axial, sagital and coronal images, oblique projections at different angles were obtained to overcome the overlapping lumbar arteries, bowel loops and for better delineation of single renal arteries with very short common stem and early division that may be mistaken as double.

Table (4): Amount of C.M Required in MR angiography among the 35 donors

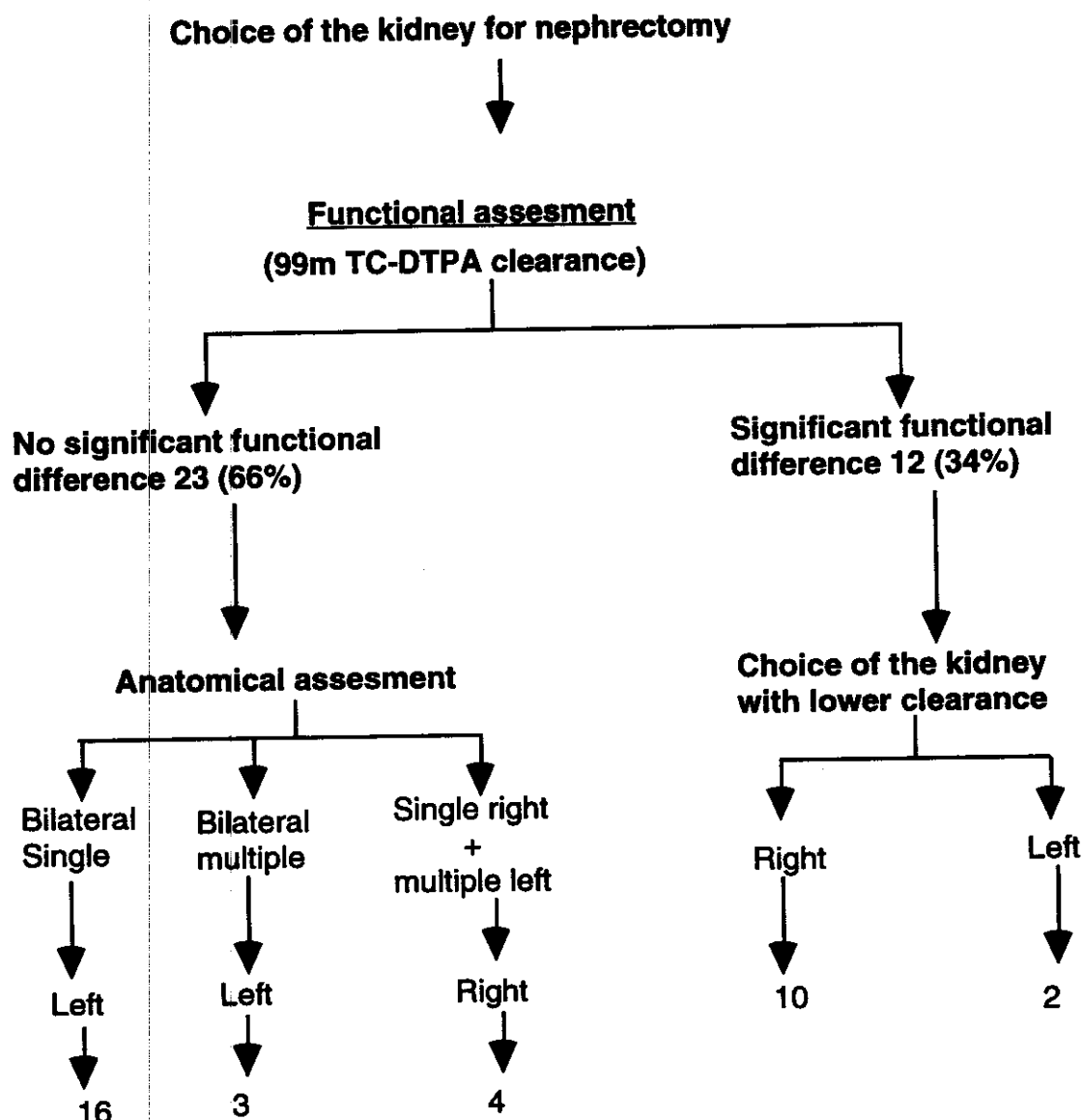| Technique	Amount of C.M	Number of donors	%
MRangiography	30 cc	26	74%
	40 cc	6	17%
	50 cc	3	9%
Total	---	35	100%

Among the 35 donors the right kidney was harvested in 14 cases (40%) and the left kidney in 21 cases (60%) according to functional assesment of both kidneys using ($99m$ TC-DTPA) significant functional differences between both kidneys (more than 15 ml/ min. in $99m$ TC-DTPA clearance) was found in 12 cases (34%), while no significant functional difference in 23 cases (66%).

Fig. (7): Amount of C.M. Required in MR angiography among the 35 donors
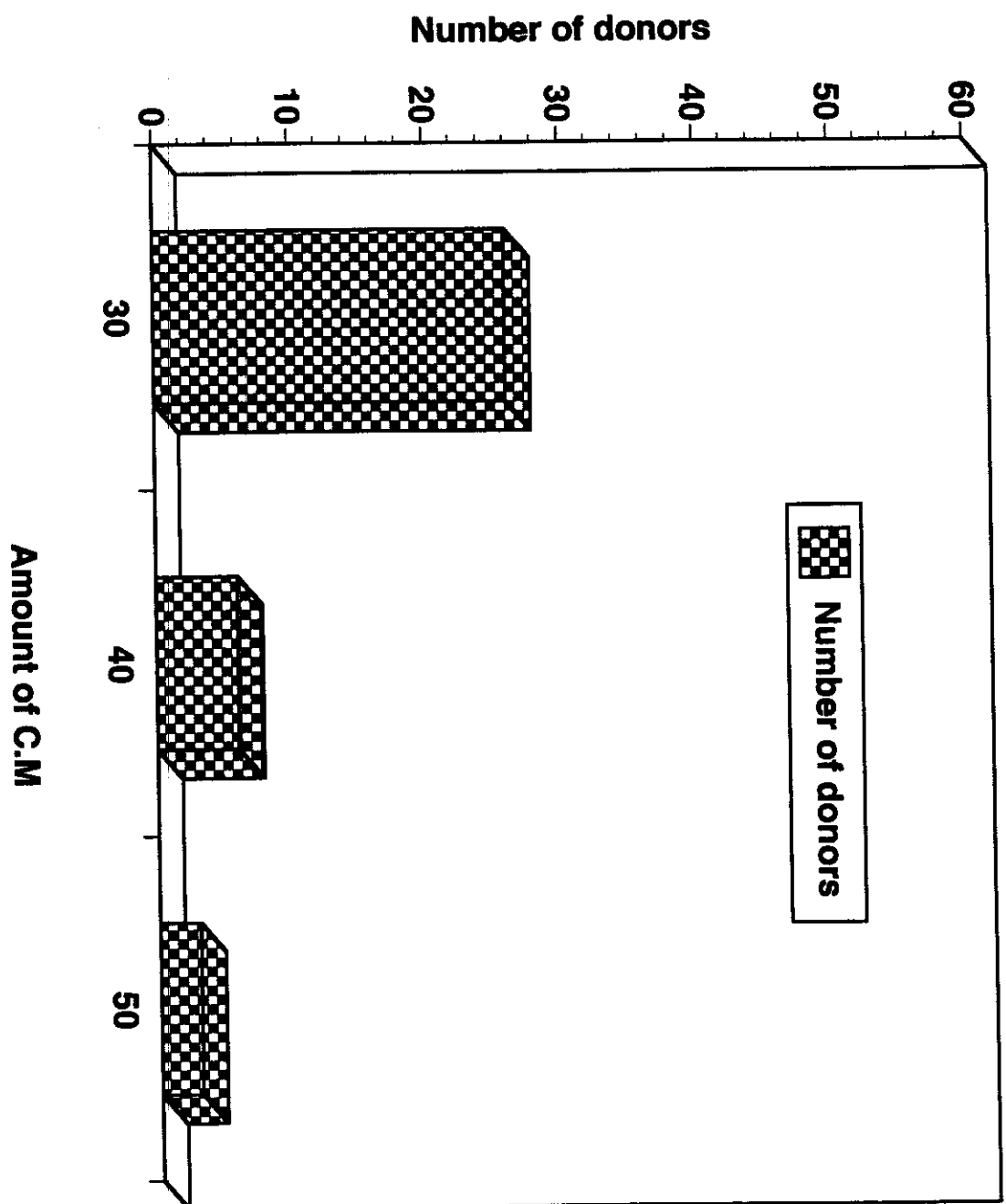
In the first 12 cases the kidney with lower clearance was chosen for nephrectomy irrespective of the anatomical findings, aiming at preservation of the kidney with higher clearance value to the donor, and according to this base, the left kidney was harvested in 2 cases while the right kidney was harvested in 10 cases. In the other 23 cases where no significant functional difference was present, the choice of the kidney for nephrectomy was according to the anatomical point, in these 23 cases bilateral single renal arteries were found in 16 cases and so, the left kidney was harvested because of its longer renal vein and ease of transplantation. In 4 of these 23 cases, single right renal artery with multiple left renal arteries was found so, the right kidney was chosen while the remaining 3 cases have bilateral multiple vessels, so, the left kidney was chosen. The choice of the kidney for nephrectomy is demonstrated in the following scheme:-

Choice of the kidney for nephrectomy

↓

Functional assesment

(99m TC-DTPA clearance)

No significant functional difference 23 (66%)	**Significant functional difference 12 (34%)**

No significant functional difference 23 (66%)

↓

Anatomical assesment

Bilateral Single	Bilateral multiple	Single right + multiple left
↓	↓	↓
Left	Left	Right
↓	↓	↓
16	3	4

Significant functional difference 12 (34%)

↓

Choice of the kidney with lower clearance

Right	Left
↓	↓
10	2

In the 35 donors who were subjected to nephrectomy, the operative results regarding the number of renal arteries were :- single renal artery in 24 harvested kidney (69%), double arteries in 10 cases (28%), while triple arteries supplying the kidney were found in 1 case (3%) [table (5) & Fig. (8)].

Table (5) : Number and percentage of renal arteries detected at nephrectomy.

Number of arteries at nephrectomy	Number of cases	%
Single artery	24	69%
Double arteries	10	28%
Triple arteries	1	3%
Total	35	100

The number of renal arteries detected at nephrectomy was compared to that predicted by IV-DSA, IA-DSAortgraphy, I.A-selective renal angiography and MRangiography, and sensitivity, specificity and overall accuracy of each technique were calculated. The proportion of surgically confirmed single renal arteries was defined as true positive rate (sensitivity) and that of surgically confirmed multiple (double) renal arteries was defined as true negative rate (specificity).

In our study, 24 single arteries and 10 double arteries were detected intraoperatively. In I.V-DSA, 23 cases were diagnosed as single arteries and confirmed surgically to be single, 6 cases were diagnosed single and proved to be double arteries intraoperatively, 4 cases diagnosed as double arteries and confirmed to be double, while one case was diagnosed as double arteries and proved to be single during nephrectomy.

Fig. (8): Number of renal arteries detected at nephrectomy

Number of cases

Number of arteries at nephrectomy
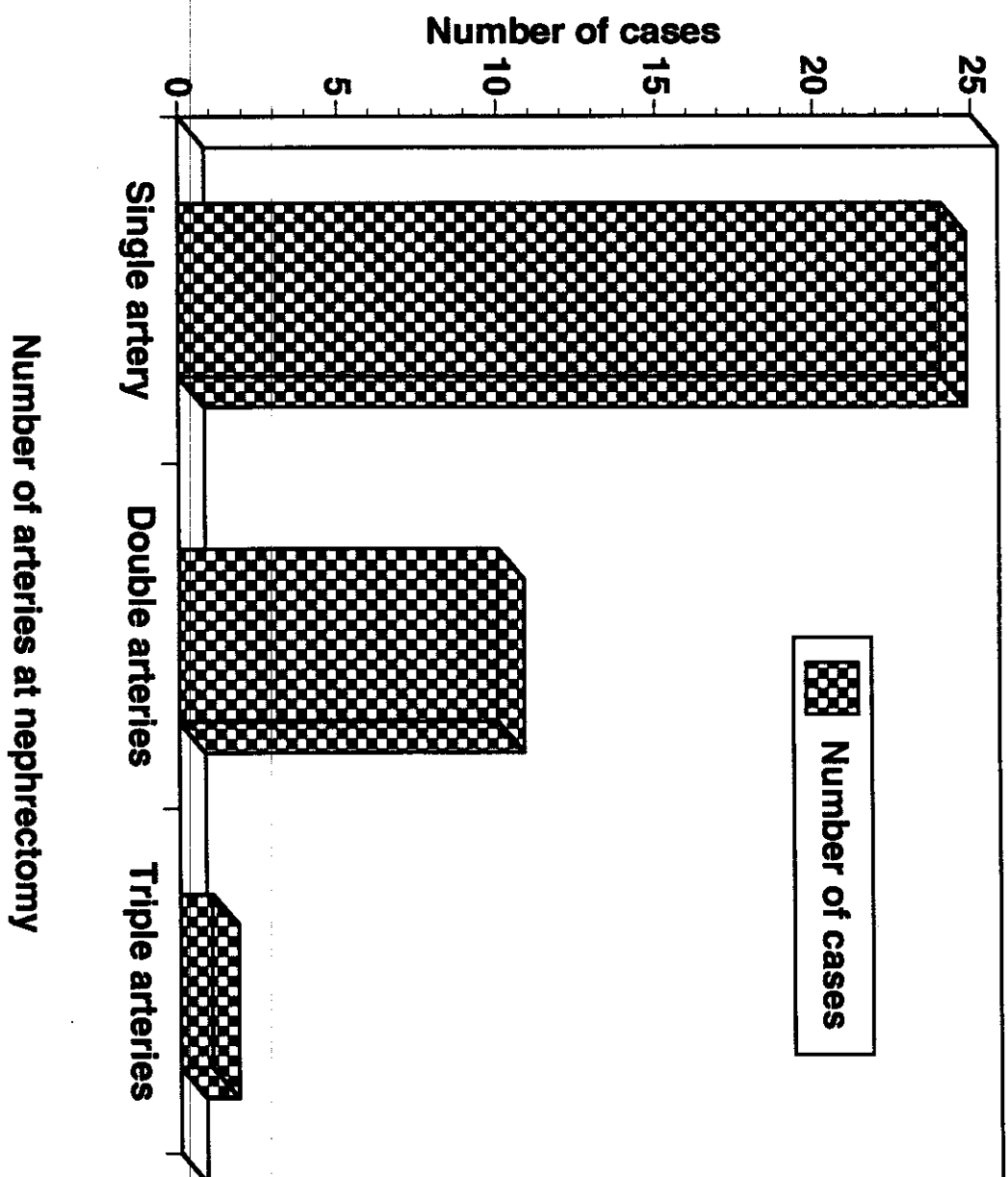
In I.A-DSAortography, 24 cases were diagnosed as single arteries and confirmed surgically to be single, 3 cases were diagnosed single and proved to be double arteries, 7 cases were diagnosed as double arteries and confirmed to be double, while no cases were diagnosed as double arteries and proved to be single.

In I.A-selective renal angiography, all the 24 cases which were diagnosed as single arteries were confirmed surgically as being single, 1 case was diagnosed as single artery and proved to be double, 9 cases were diagnosed as double arteries and detected to be double, while no cases were diagnosed double and proved to be single.

In MRAngiography, 24 cases were diagnosed as single arteries and confirmed surgically to be single, 2 cases were diagnosed single and proved to be double arteries, 8 cases diagnosed as double arteries and confirmed at operation to be double, while no cases were diagnosed as double arteries and proved to be single [Table (6) & (Fig. (9)].

Table (6): Agreement between the number of arteries detected at nephrectomy and IV-DSA, IA-DSAortography, IA-selective renal angiography and MRAngiography.

No. of arteries predicted	Actual No. of arteries at nephrectomy	
	Single	Double
Total No. of cases	24	10
I.V-DSA		
• single	23	6
• Double	1	4
I.A-DSAortography		
• single	24	3
• Double	0	7
I.A-selective renal angiography		
• single	24	1
• Double	0	9
MRAngiography		
• single	24	2
• Double	0	8

The sensitivity, specificity and overall accuracy of each technique are given in [Table (7) & Fig. (10)].

Table (7): The sensitivity, specificity and overall accuracy in all techniques.

| Technique	Sensitivity	Specificity	Accuracy
I.V-DSA	95.8%	40%	77%
I.A-DSAortography	100%	70%	88.5%
I.A-selective renal angiography	100%	90%	94.2%
MRAngiography	100%	80%	91.4%

The positive and negative predictive values of all techniques are given in [Table (8) & Fig (11)].

Table (8): The positive and negative predictive values of all techniques.

Technique	Positive predictive value	Negative predictive value
I.V-DSA	79%	80%
I.A-DSAortography	88.9%	100%
I.A-selective renal angiography	96%	100%
MRAngiography	92.3%	100%

Analysis of the data of our study revealed sensitivity 95.8% and specificity 40% for I.V-DSA, sensitivity 100% and specificity 70% for I.A-DSAortography, sensitivity 100% and specificity 90% for I.A-selective renal angiography versus 100% and 80%

Fig. (9): Agreement between the number of arteries detected at nephrectomy and IV-DSA, IA- DSAortography, IA-selective renal angiography and MRAngiography.
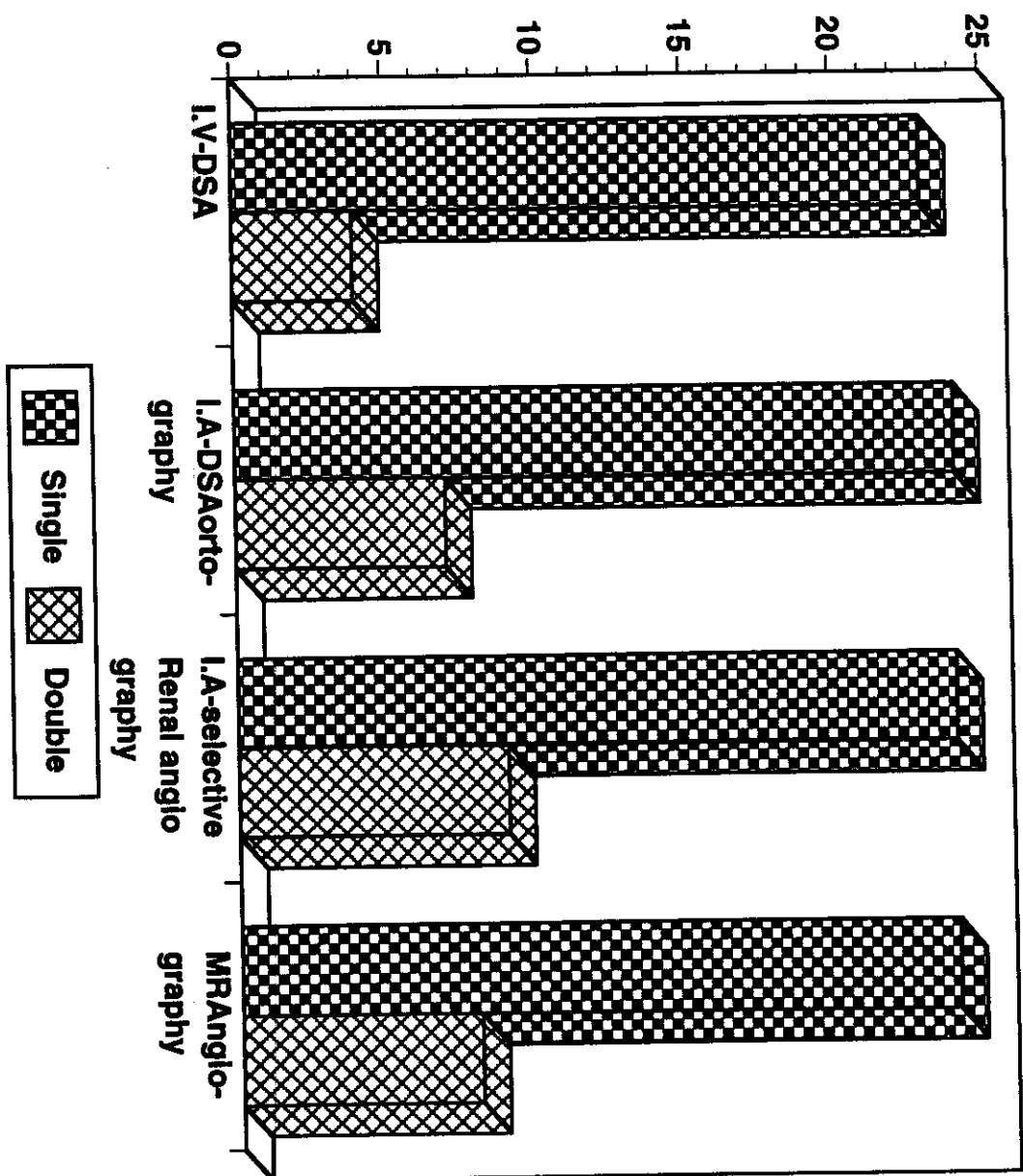
Fig. (10): The sensitivity, specificity and overall accuracy in all techniques

Fig. (11): The positive and negative predictive values of all techniques

Legend:
- Positive (checkered)
- Negative (cross-hatched)

Categories: I.V-DSA, I.A-DSA, I.A-selective renal, MrAngiog.
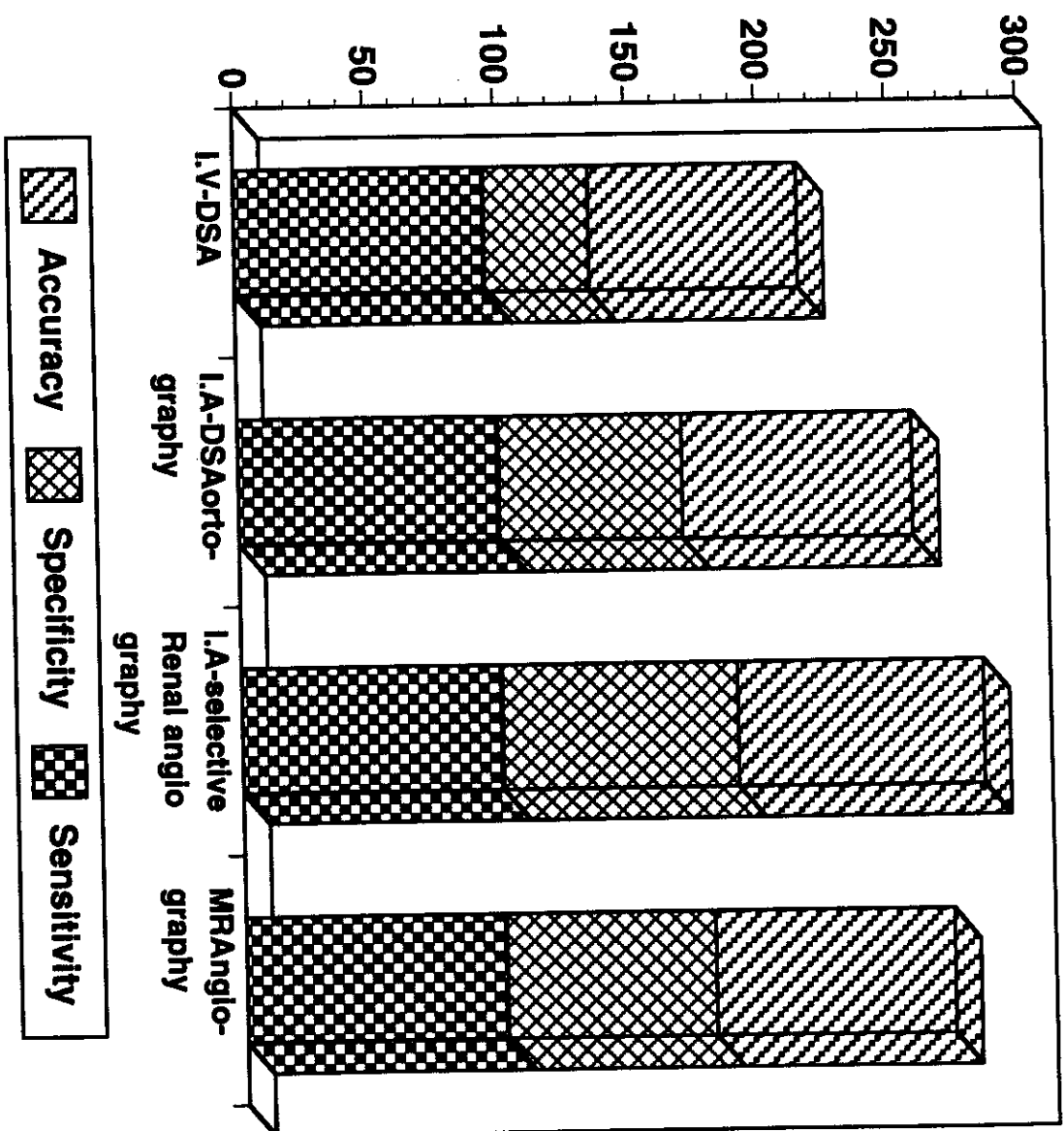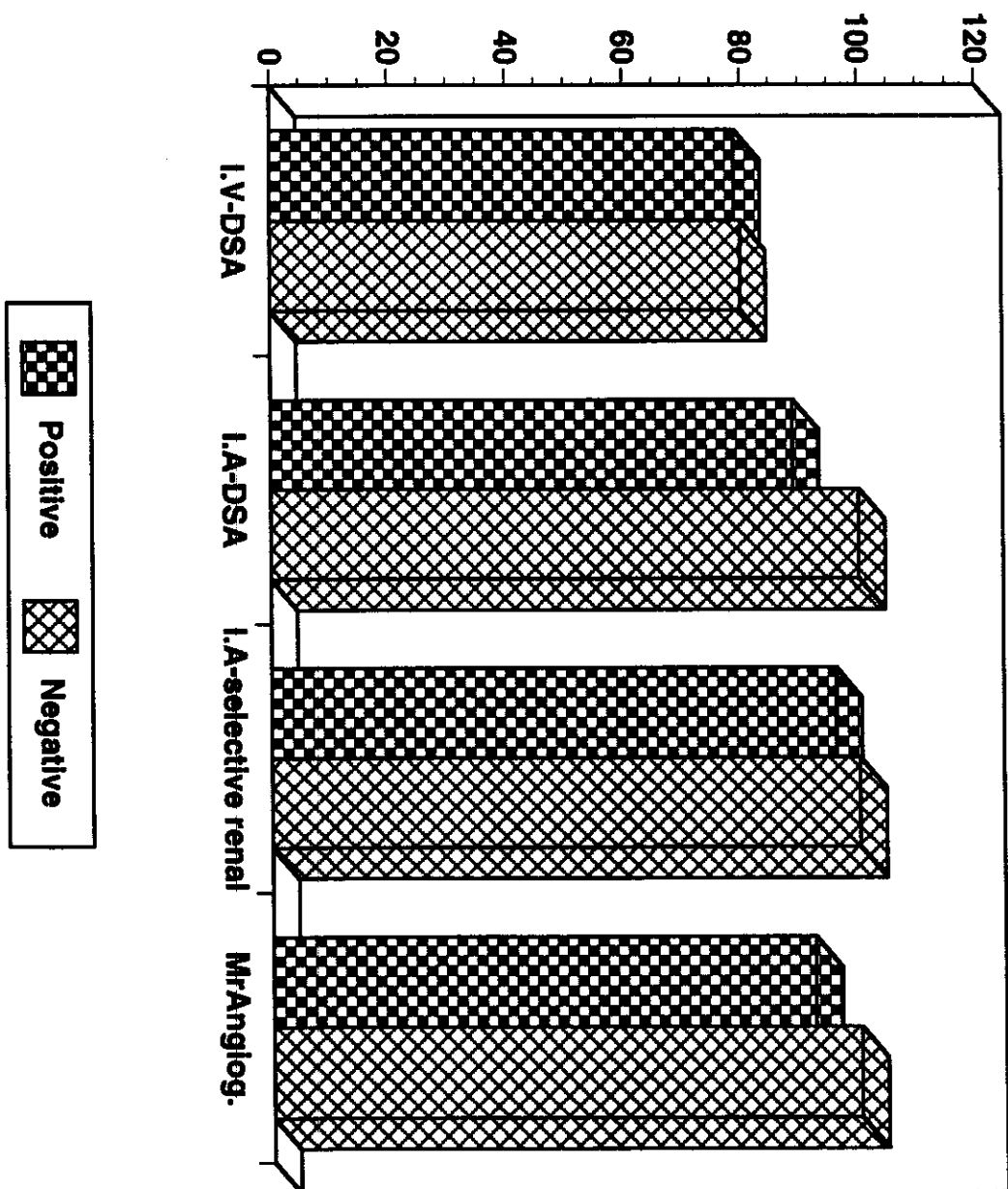
respectively for MRAngiography . Overall accuracy was 77%, 88.5%, 94.2% and 91.4% for I.V -DSA, I.A-DSAortography, I.A-selective renal angiography and MRAngiography respectively . Compared to 95.8%, 100% for single renal arteries by I.V-DSA and other techniques respectively and 40%, 70%, 90%, and 80% respectively for double arteries . All technique were interpreted as showing double arteries in the case with triple renal arteries .

The observations in IV-DSA , IA-DSAortography, IA-selective renal angiography and MRAngiography as regarding the number of renal arteries, peri-hilar branching, renal parenchymal and collecting system abnormalities were correlated with the intra-operative findings and overall accuracy of each technique was determined .

Overall accuracy for detection of peri-hilar branching were 50%, 83.3%, 100% and 83.3% for I.V-DSA, I.A-DSAortography, I.A-selective renal angiography and MRAngiography respectively . Table(9) & Fig(12) . All renal arteries of all donors in the study were normal with no evidence of stenosis or aneurysmal dilatation also, no detectable parenchymal or collecting system abnormalities.

Table (9):The accuracy of all techniques in visualization of the number of renal arteries, peri-hilar branching, renal parenchymal and collecting system anomalies

Operative findings	Number of donors	I.V-DSA	I.A-D SAortograpgy	I.Aselective renal angiography	MR angiography
single artery :	24				
Correct number		23	24	24	24
Misinterpreted number		1	0	0	0
% accuracy		95.8%	100%	100%	100%
Double arteries :	10				
Correct number		4	7	9	8
Misinterpreted number		6	3	1	2
% accuracy		40%	70%	90%	80%
Triple arteries :	1				
Correct number		0	0	0	0
Misinterpreted number		1	1	1	1
% accuracy		0%	0%	0%	0%
Peri-hilar branching:	6				
Correct number		3	5	6	5
Misinterpreted number		3	1	0	1
% accuracy		50%	83.3%	100%	83.3%

Fig. (12): The accuracy of all techniques in visualization of the number of renal arteries, peri-hilar branching, renal parenchymal and collecting system anomalies
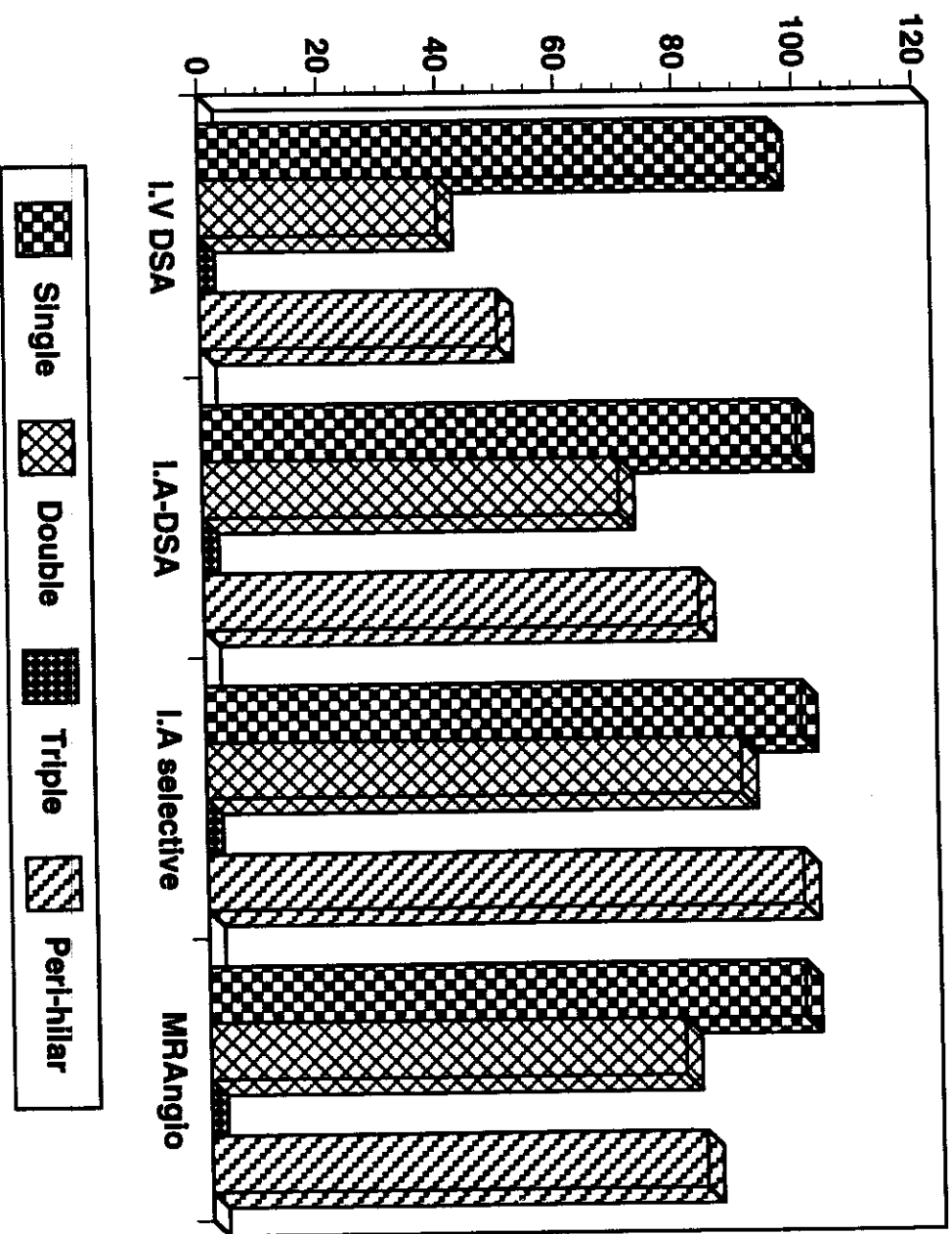
Among the 35 studies with postprocessing 3-D reconstruction using MIP imaging, 25 donors were further subjected to multiplanar reformation (MPR) imaging as another postprocessing modality, the number of renal arteries detected at nephrectomy was compared to that predicted by each technique, and sensitivity, specificity and overall accuracy of each technique were calculated . In our study 19 single renal arteries and 6 double arteries were detected intraoperatively . In MIP images 18 cases were diagnosed as single arteries and confirmed to be single , 2 cases were diagnosed single and proved to be double arteries, 4 cases diagnosed as double arteries and confirmed surgically to be double, while one case was diagnosed as double arteries and proved to be single during nephrectomy.

In multiplaner reformation (MPR) images, 19 cases were diagnosed as single arteries and confirmed surgically, 1 case was diagnosed as single and proved to be double, 5 cases were diagnosed as double arteries and confirmed surgically to be double, while no cases were diagnosed as double arteries and proved to be single during nephrectomy . [Table (10) & Fig (13)].

Table (10):Agreement between the number of arteries detected at nephrectomy and MRAngiography (ultilizing both MIP images and MPR in 25 donors) :

No. of arteries predicted	Actual No.of arteries at nephrectomy	
	Single	Double
Total No. of cases	19	6
MIP :-		
Single	18	2
Double	1	4
Multiplanar reformation :-		
Single	19	1
Double	0	5

The sensitivity, specificity and overall accuracy of each technique are given in [Table (11) & Fig (14)].

Table (11):The sensitivity, specificity and overall accuracy of MIP and MPR images in 25 donors :

Technique	Sensitivity	Specificity	Accuracy
MIP	94.7%	66.6%	88%
MPR	100%	83.3%	96%

Fig. (13): Agreement between the number of arteries detected at nephrectomy and MRAngiography (ultilizing both MIP images and MPR in 25 donors)
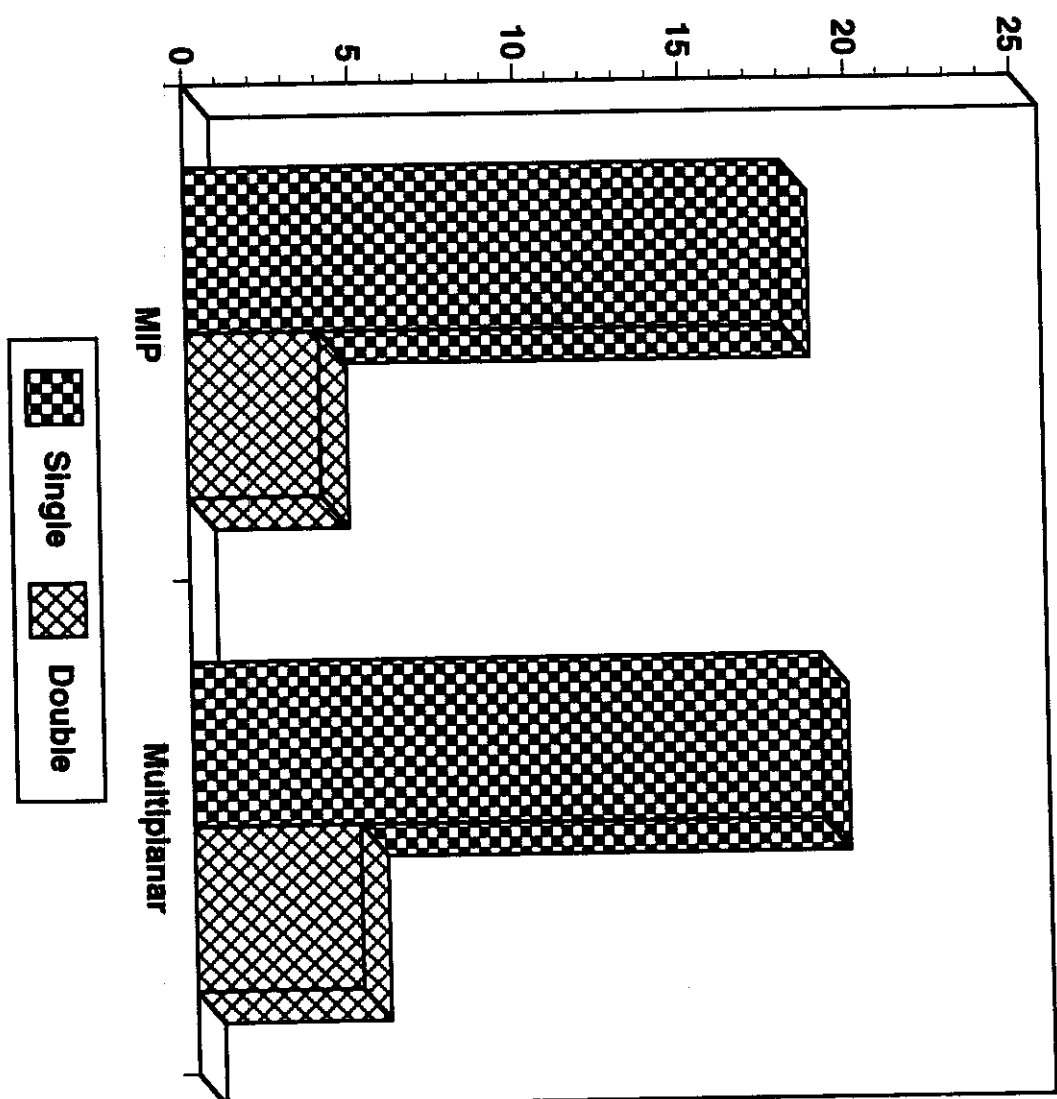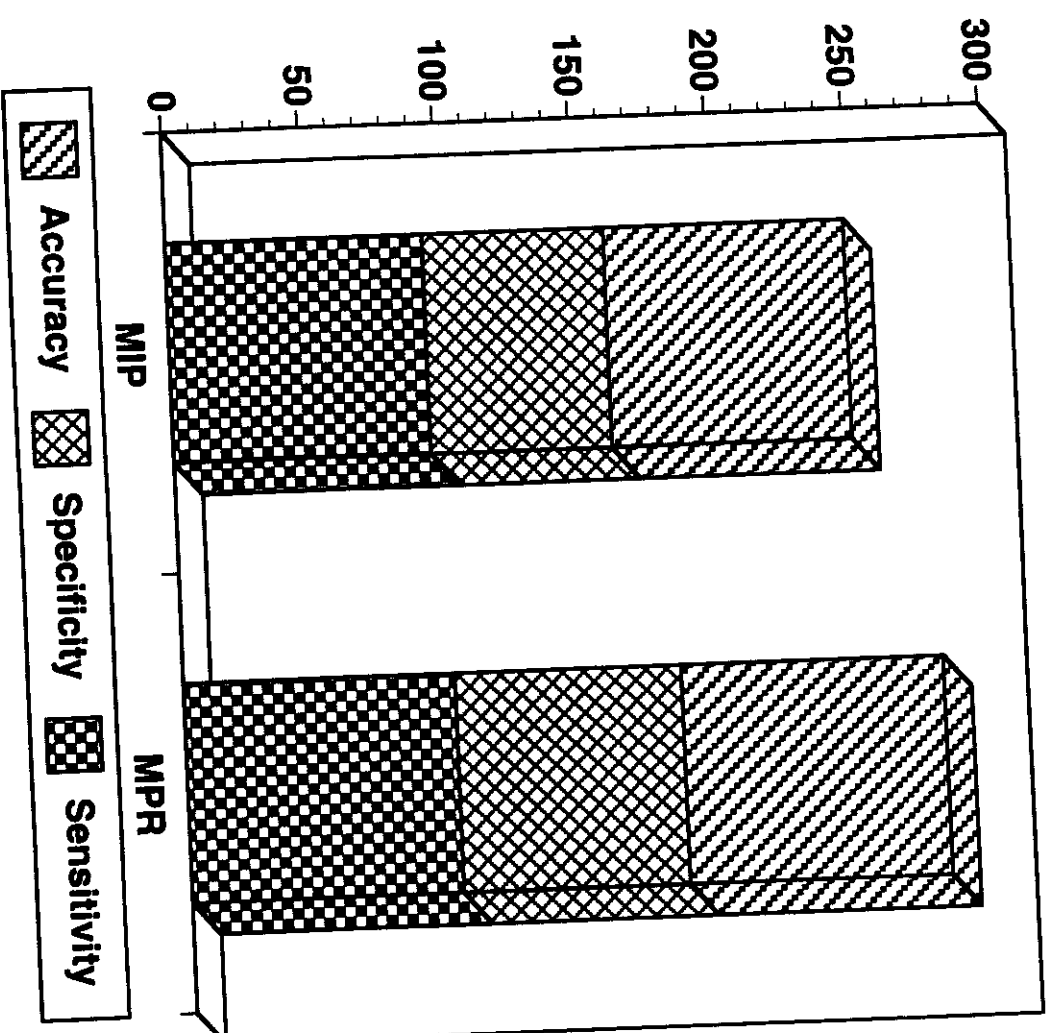
Fig. (14): The sensitivity, specificity and overall accuracy of MIP and MRP in 25 donors

In our study3 cases having double renal veins, 2 circum-aortic left renal veins and 4 retro-aortic left renal veins were detected intra-operatively . In I.V-DSA, No such venous anomalies

were recognised. In I.A- DSA, one case having double renal

veins,1circum-aortic left renal vein and 2 retro-aortic left renal veins were diagnosed with overall accuracy, 33% for multiplicity of renal veins, 50% for each other anomaly . In I.A-selective renal angiography, three cases having double renal veins, 2 circum-aortic left renal veins and 3 retro-aortic left renal veins with overall accuracy 100%, 100% and 75% respectively . In MRA, three cases having double renal veins 2circum-aortic left renal veins and 4 retro-aortic left renal veins with overall accuracy 100% for each as confirmed surgically . Table (12) & Fig. (15).

Table (12):- The accuracy of all techniques in visualization of renal venous anomalies.

Operative findings	Number of donors	I.V-DSA	I.A-DS Aortograpgy	I.A-selective renal angiog	MRA
• Double renal veins					
• Correct number	3	0	1	3	3
• Misinterpreted number		3	2	0	0
• % Accuracy.		0%	33%	100%	100%
• Circum-aortic It renal vein:-					
• Correct number	2	0	1	2	2
• Misinterpreted number		2	1	0	0
• % Accuracy.		0%	50%	100%	100%
• Reto-aortic It renal vein:-					
• Correct number	4	0	2	3	4
• Misinterpreted number		4	2	1	0
• % Accuracy.		0%	50%	75%	100%

Fig. (15): The accuracy of all techniques in visualization of renal venous anomalies