

Comparison between plain x-ray abdomen and CT abdomen for detection of vascular calcification in chronic kidney disease patients

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Abstract

Background: Vascular calcification in chronic kidney disease patients on dialysis is associated with increased cardiovascular morbidity and mortality, increased difficulty in forming vascular anastomoses (vascular grafts or AV fistulae) and performing successful coronary artery interventions (angioplasty, stenting, and coronary artery bypass grafting).

Objectives: Primary objective was to find the sensitivity and specificity of plain X-ray abdomen lateral view for detection of vascular calcification in CKD patients on hemodialysis. Finding the association of various clinical and biochemical parameters with vascular calcification in CKD patients on hemodialysis and comparing the two year survival of patients with and without vascular calcification were the secondary objectives.

Materials and Methods: CKD patients aged between 18-80 years undergoing hemodialysis for at least three months from a tertiary care hospital of South India were selected. Patients were enrolled between March 2014 and August 2014. Clinical and biochemical parameters of these patients were recorded. Plain X-ray abdomen lateral view and non contrast CT abdomen of these patients were taken. X-ray and CT image were reported by separate radiologists blinded to each other. All the patients were followed up for 2 year.

Results: Out of the 80 patients, 62 (77.5%) were males. Mean age of the study population was 49.9 ± 12.2 years. Vascular calcification was present on CT in 63 patients and on X-ray in 32. Compared to CT abdomen, X-ray abdomen had a sensitivity of 47.6% and specificity of 88.2% for detecting vascular calcification. Age was found to be a significant risk for vascular calcification with odds ratio 1.213 (95% CI 1.103-1.334), $P < 0.001$. No statistical significance was obtained for male sex, dialysis vintage time and diabetic nephropathy. C-reactive protein level had significant association with an odds ratio of 1.138 (95% CI 1.016-1.274). Point estimation of serum calcium, phosphorus, albumin, and calcium phosphorus product did not have any significant association. Two year survival was 71.4% when vascular calcification was visible on CT abdomen ($P = 0.468$), and 56.3% when vascular calcification on visible on plain X-ray abdomen ($P = 0.008$).

Conclusion: Plain X-ray abdomen lateral view can be considered as the investigation of choice for routine screening as it is cheap, non invasive, have better cost benefit ratio with lesser radiation when compared to CT abdomen, high specificity, and picks up calcifications that are clinically more relevant.

Keywords: Chronic kidney disease, Vascular calcification, Dialysis, Plain X-ray.

Introduction

Vascular calcification (VC) is a common problem in chronic kidney disease (CKD) patients on dialysis, even in very young patients. It is well accepted that calcification in the coronary arteries is the main culprit for higher incidence of coronary artery disease and sudden cardiac death in CKD patients.¹⁻⁴ VC occurs predominantly in the media of blood vessels in CKD patients resulting in increased stiffness of the arteries. This reduced vascular compliance may lead to increased pulse pressure, reduced coronary perfusion, and abnormal autonomic, and endothelial vasomotor, functions.⁶⁻¹⁰ Various risk factors are implicated in vascular calcification; raised serum calcium, increased calcium phosphorus product in the blood, hyperparathyroidism, calcium and vitamin D supplementation, increasing age, dialysis vintage, dyslipidemia, presence of diabetes, and increased pulse pressure.

The gold standard technique for the detection and quantification of VC is the histological examination of post-mortem arterial specimens. The simplest technique for detecting VC is plain radiography, which have the advantage of being cheap and noninvasive and also give some degree of differentiation between intimal and medial calcification. The 2009 KDIGO guidelines have endorsed the use of plain

lateral abdominal X-ray films to detect the presence of vascular calcification.⁵ CT scanning permits both the detection and quantification of the extent and severity of VC (although it does not differentiate between intimal and medial calcium deposition). Coronary artery calcification using special scanners and software has been also studied.

It is important to detect vascular calcification in CKD patients by routine screening as the presence of which is associated with increased cardiovascular morbidity and mortality, increased difficulty creating vascular anastomoses (vascular grafts or AV fistulae) and performing successful coronary artery interventions (angioplasty, stenting, and coronary artery bypass grafting).¹¹ Vascular calcification if detected, strategies to prevent further progression should be initiated. The cost benefit ratio of using CT abdomen for routine screening for VC is not in the favorable side; hence we aim to delineate the role of plain X-ray abdomen for the same.

Primary objective

To find the sensitivity and specificity of Plain X-ray abdomen lateral view for detection of vascular calcification in chronic kidney disease patients on hemodialysis.

Secondary objectives

1. To find the association of various clinical and biochemical parameters with vascular calcification.
2. To compare the two year survival of patients with and without vascular calcification.

Materials and Methods

CKD patients with age between 18-80 years undergoing hemodialysis for at least three months from the dialysis units of a tertiary care hospital of South India were selected for the study. 80 patients were enrolled between March 2014 and August 2014. Clinical and biochemical parameters of these patients were recorded. Plain X-ray abdomen lateral view and non contrast CT abdomen of these patients were done. X-ray and CT image were reported by separate radiologists blinded to each other. Sensitivity and specificity of X-ray abdomen for detection of vascular calcification was calculated, considering CT abdomen as gold standard. Association of various clinical and biochemical parameters with vascular calcification was also studied. All patients were followed up for two years or till their death whichever is earlier and their cause of mortality and major cardiovascular events were documented.

Results

Out of the 80 patients enrolled for the study, 62 (77.5%) were males. Mean age of the study population was 49.9 ± 12.2 years. Base line characteristics of the study population are tabulated in Table 1. Compared to CT abdomen, X-ray abdomen had a sensitivity of 47.6% and specificity of 88.2% for detecting vascular calcification (Table 2). Various risk factors for vascular calcification were analyzed (Table 3 & 4). Age was found to be a significant risk for vascular calcification with odds ratio 1.213 (95% CI 1.103-1.334), $P < 0.001$. No statistical significance was obtained for male sex, dialysis vintage and diabetic nephropathy as risk factors. C-reactive protein level was found to have significant association with the vascular calcification with an odds ratio of 1.138 (95% CI 1.016-1.274). Serum calcium, serum phosphorus, calcium phosphorus product, and serum albumin measured at the time of enrollment to the study had no significant association with vascular calcification.

Table 1: Base line characteristics of the study population (N=80)

Age:	
Mean Range	49.9 ± 12.2 years 18 - 78 years
Sex:	Males 62 (77.5%), Females 18 (22.5%)
Diabetic Nephropathy:	34 patients
Coronary artery disease:	25 patients
Dialysis vintage:	
Mean	2.4 ± 1.2 years
Range	0.5 - 7 years
Vascular accesses:	
Arterio-venous fistula	77
Permanent tunnelled jugular catheter	3
Corrected serum calcium:	
Mean	8.4 ± 0.9 mg/dl
Range	6.1 - 10.4 mg/dl
Serum Phosphorus	
Mean	5.7 ± 1.17 mg/dl
Range	2.9-9.1 mg/dl
Calcium Phosphorus Product	
Mean	48.0 ± 12.2 mg ² /dl ²
Range	20.9 – 91.9 mg ² /dl ²
Alkaline Phosphatase	
Mean	139.8 ± 65.6 IU
Range	41 – 446 IU
C - Reactive Protein	
Mean	9.2 ± 6.4 mg/dL
Range	1.0 – 21.0 mg/dL
Serum albumin	
Mean	3.2 ± 1.4 g/dL
Range	2.1 – 4.2 g/dL
Vascular calcification on CT abdomen	63 patients (78.8%)
2 year survival	58 patients (72.5%)
Cause of death (n=22)	Sudden cardiac death: 18 Sepsis: 1 Pneumonia: 1 Cause unknown: 2

Table 2: Plain X-ray Abdomen vs CT Abdomen for detecting vascular calcification

Vascular Calcification on X- RAY	Vascular Calcification on CT		Total
	Absent	Present	
Absent	15	33	48
Present	2	30	32
Total	17	63	80

Sensitivity of Plain X-ray abdomen lateral view for detecting calcification: 47.6% Specificity of Plain X-ray Abdomen lateral view for detecting vascular calcification: 88.2%

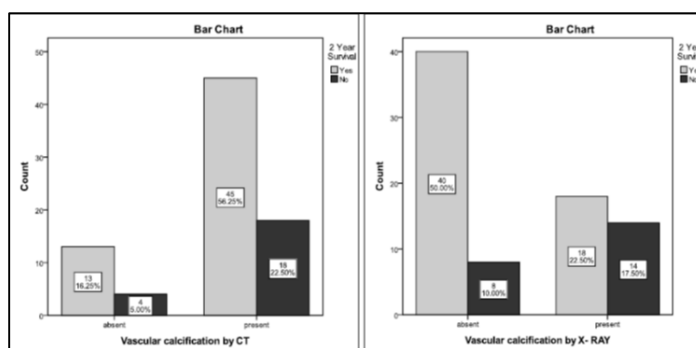
Table 3: Risk factors for vascular calcification in CKD stage V D

	P value	Odds ratio	95% C.I	
			Lower	Upper
Age	<.001	1.213	1.103	1.334
Male sex	.406	2.099	.365	12.071
Dialysis vintage time	.926	1.025	.611	1.718
Diabetic nephropathy	.548	1.621	.335	7.841

Table 4: Association of biochemical parameters (point measurement at the time of enrolling to the study) with vascular calcification

	P value	Odds ratio	95% C.I	
			Lower	Upper
Serum albumin	.784	.838	.236	2.976
Serum calcium	.859	.751	.032	17.781
Serum phosphorus	.610	.287	.002	34.616
Calcium phosphorus product	.611	1.157	.659	2.032
Alkaline phosphatase	.656	1.002	.992	1.013
C-Reactive Protein	.025	1.138	1.016	1.274

Two year survival was 72.5% in the study population (22 deaths during the 2 year follow up). 63 patients had vascular calcification visible on CT abdomen (Fig. 1 a), out of which 18 patients died (P=0.468). 32 patients had vascular calcification on visible on plain X-ray abdomen (Fig. 1 b), out of which 14 patients died (P=0.008).

**Fig. 1: a & b:** 2 Year survival of Patients with CKD stage V D

Discussion

In this study, 40% patients on hemodialysis had vascular calcification detected by X-ray abdomen, which is similar to the observation by Goldsmith DJ et al where 39% patients had calcification.¹² The sensitivity of X-ray abdomen for detection of vascular calcification was 47.6% and specificity was 88.2%. Plain X-ray can be considered as the first screening modality for detecting VC in view of high specificity. Even though the sensitivity of Plain X-ray is poor, VC picked on the plain X-ray was more significant than picked on the CT abdomen, as 2 year survival is significantly

reduced if calcification is visible on X-ray. 2 year survival of patients with VC on CT abdomen was 71.4% where it was only 56.3% when VC was visible on plain X-ray. This is probably because of CT is more sensitive to pick up milder degrees of calcifications with less clinical implications.

Various risk factors for vascular calcification were analyzed in this study. Age was found to be a significant risk. Age is an independent risk factor for VC, even in patients without CKD.¹³ Dialysis vintage, an established risk factor for VC was found not to be a significant risk factor, probably because most of patients were having a short dialysis vintage (mean of 2.4 years). Diabetic nephropathy was also not a

significant risk for VC probably because advanced age and diabetic nephropathy became confounding factors when logistic regression analysis was performed. C-reactive protein level had significant association with the vascular calcification suggesting chronic inflammatory state in the pathogenesis of VC. Derangements in the calcium and phosphorus metabolism is implicated in the pathogenesis of VC,¹⁴ but point estimation of serum calcium, phosphorus, and calcium phosphorus product did not had any significant association with vascular calcification. Long term trends in these biochemical parameters are more important than point estimation.

Conclusions

Routine screening for vascular calcification in CKD patients on dialysis is important as it is associated with increased cardiovascular morbidity and mortality, increased difficulty forming vascular anastomoses (vascular grafts or AV fistulae) and performing successful coronary artery interventions (angioplasty, stenting, and coronary artery bypass grafting). Plain X-ray abdomen lateral view can be considered as the investigation of choice for routine screening as it is cheap, non invasive, better cost benefit ratio and lesser radiation when compared to CT abdomen, high specificity, and picks up calcifications that are clinically more relevant.

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Conflict of Interest

None.

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