Cranial and Caudal Angulation for Coronary Angiography Revisited

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SUMMARY Several similar projections utilizing cranial and caudal angulation of the X-ray tube in various obliquities have been described recently for coronary angiography and left ventriculography. These views provide improved visualization of the proximal branches of the left coronary artery, the region of the crux of the right coronary artery, and the left ventricle in the left anterior oblique projection; structures which in the conventional projections are often superimposed on one another or are foreshortened.

UNTIL recently cineangiograms and serial individual films of the coronary arteries and left ventricle (LV) were obtained with the X-ray beam perpendicular to the long axis of the patient. This technique produces considerable overlap and foreshortening of the proximal branches of the left anterior descending coronary artery (LAD) and of the branches of the right coronary artery (RCA) at the crux. Multiple oblique, AP and lateral views using the perpendicular beam often cannot overcome this problem. Similarly, complete evaluation of left ventricular contractility is difficult. In the 30° right anterior oblique (RAO) projection, the definition of anterior and diaphragmatic wall motion is relatively accurate, but unfortunately in the 60° left anterior oblique (LAO) projection, the apex and base are superimposed and the septal and true posterior walls of the LV are foreshortened and partially obscured. Several authors have almost simultaneously described additional views in multiple obliquities utilizing cranial and caudal angulation of the X-ray beam. A number of confusing and conflicting terms have been applied to these projections resulting in the description of identical views carrying different names. Several radiographic techniques are available, but the terminology describing the projections must be standardized for the results to be compared and reproduced.

Nomenclature
We propose the following terminology, adapted and simplified from Lesperance et al. and Aldridge et al., to describe cranial and caudal angulation of the X-ray source and the obliquity of the patient.

The confusing and conflicting terms — “oblique clockwise and anticlockwise table base turn,” “half-axial,” “angulated,” “sit up,” “caudo-cranial sagittal angulation,” “cranio-caudal sagittal angulation,” and “lordotic” projections — should be discarded in favor of the terms “cranial angulation projection” and “caudal angulation projection.” The appropriate anterior, rather than the posterior obliquity should be used to refer to rotation of the patient, or the X-ray beam around his long axis.

I. Cranial and Caudal Angulation of the X-ray Beam (table 1)

A. Cranial Angulation Projection

This projection is obtained by cranial angulation of an X-ray source entering the chest posteriorly and exiting anteriorly or any equivalent radiographic projections. Cranial angulation in different obliquities has been described as left oblique clockwise table base turn (cranial) projection, angulated beam, sit-up views, and cranio-caudal sagittal angulation. The lordotic LAO projection obtained by cranial angulation of an X-ray beam entering the chest posteriorly, described by Sos et al., and the half-axial RPO view described by Bunnell et al., are variant techniques of obtaining cranial angulation projections.

B. Caudal Angulation Projection

This is the projection obtained by directing the X-ray beam caudally with a posterior entrance to the chest and an anterior exit. Any equivalent radiographic projection should carry the same name. Thus a cranial beam entering anteriorly and exiting posteriorly will result in the same projection. Caudal angulation in several obliquities has been used to obtain left oblique anticlockwise table base turn (caudal) projection, lordotic RPO, angulated beam, caudo-cranial sagittal angulation, and lordotic RAO projections.

The cranial or caudal angulation may be produced by changing the position of the patient (fig. 3A, 3B), or by tilting the X-ray source (figs. 1A, 1B, 2A, 2B). The X-ray tube may be located in front of or behind the patient’s chest, and it may be vertical (fig. 1A, 1B) or horizontal (fig. 2A, 2B). It is important to understand that it is the angulation of the X-ray beam, not its point of entry into the chest, which determines the resulting radiographic projection. For uniformity, all projections utilizing cranial or caudal angulation will be defined as obtained by X-ray beams with a posterior entrance into the chest, regardless of whether the X-ray source is anterior or posterior.

Thus, the cranial tilt of a radiographic beam entering the patient’s chest posteriorly and exiting on the anterior surface produces the radiographic equivalent of cranial angulation of a beam entering the chest from the anterior surface and
TABLE 1. Recommended and Previously Used Terminology for Cranial and Caudal Angulation Projection in Coronary Angiography

<table>
<thead>
<tr>
<th>Cranial angulation projection</th>
<th>Caudal angulation projection</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAO</td>
<td>Left oblique clockwise table base turn* (cranial)</td>
</tr>
<tr>
<td>Half axial RPO</td>
<td>Lordotic RPO</td>
</tr>
<tr>
<td>Half axial left ventricular angiogram</td>
<td>Angulated beam</td>
</tr>
<tr>
<td>Sit up view</td>
<td>Cranio-caudal sagittal angulation</td>
</tr>
<tr>
<td>Lordotic LAO</td>
<td></td>
</tr>
<tr>
<td>RAO</td>
<td>Cranio-caudal sagittal angulation</td>
</tr>
<tr>
<td></td>
<td>Lordotic RAO</td>
</tr>
</tbody>
</table>

*These terms describe settings on Siemens Cardioskope - U. and do not refer to the position of the patient.

Abbreviations: LAO = left anterior oblique; RAO = right anterior oblique; RPO = right posterior oblique.

II. Obliquity of the Patient (table 1)

By convention, in radiology, the position of the patient with regard to the film has been used as the reference point.

A. Left Anterior Oblique (LAO)

A patient lying supine with the left side of the chest elevated 60° would be in the 60° LAO position to a cine camera above the table and in the 60° RPO position to X-ray film located below the table.

B. Right Anterior Oblique (RAO)

A 30° elevation of the right side of the chest of a supine patient would result in a 30° RAO position to an overhead cine camera and a 30° left posterior oblique (LPO) position with regard to a film under the table.

Conventionally, in coronary angiography, the radiographically equivalent anterior obliquity is used to describe the patient positioning regardless of the location of the film and the X-ray source; thus, the equally correct but confusing nomenclature of posterior obliques should be abandoned in favor of the terms LAO and RAO. In the 60° LAO projection, the interventricular septum is perpendicular to the film and is seen on end; whereas, in the 30° RAO projection, the interventricular septum is in a plane parallel to the film and is seen en face.

![Figure 1](http://circ.ahajournals.org/)

**Figure 1. Techniques for cranial and caudal angulation using a vertical X-ray beam.** A) Positioning for LAO cranial and caudal angulation. B) Positioning for RAO cranial and caudal angulation. These illustrations demonstrate the arrangement of the X-ray equipment when using fixed vertical (fig. 1) or horizontal (fig. 2) X-ray sources and serial individual film changers. The patient must be rotated along his long axis into the desired obliquity. Isocentric units perform cranial and caudal angulation and allow rotation of the imaging system around the long axis of the stationary supine patient between these two extremes (vertical and horizontal X-ray beams). Note that the X-ray beam may originate in front of or behind the patient's chest. The diagrams of the coronary angiograms have been rotated into the conventional viewing position in figures 1A, 1B, 2A, and 2B.

FIGURE 3. Techniques for cranial angulation projection using angulation of the patient. A) Elevation of the patient. B) Elevation of the table. Cranial angulation of the beam is produced by angulation of the patient. The diagrams illustrate the use of an under the table X-ray source and overhead cine camera. An overhead X-ray source and under the table individual serial film changer could also be used; this would reverse the direction of travel but not the angulation of the X-ray beam.
Equipment and Techniques Available to Obtain Cranial and Caudal Angulation Views

I. Angulation of the Patient

A. Elevation of the Patient (Sit-Up View) (fig. 3A)

The sit-up view is a most frequently employed simple technique. Cranial angulation is obtained by elevating the patient's chest to 30-45° and rotating the patient into the desired obliquity. Elevation may be accompanied by placing nonradiopaque inflatable pillows or sponges under the patient. This somewhat cumbersome technique necessitates either moving the patient with the catheter in the coronary artery or removal and subsequent reinsertion of the catheter. Either technique is less attractive due to additional manipulation.

B. Elevation of the X-ray Table (fig. 3B)

A Spectrum angiographic tilt table capable of 30° angulation has been introduced. Angulation is produced by passively elevating the patient, thus eliminating additional catheter manipulation.

II. Angulation of the X-ray Source (figs. 1A, 1B, 2A, 2B)

A. Cine and Spot Film Cameras

1. Isocentric Units (U, C, L-arm and Parallelogram). These isocentric (the heart of a stationary patient, once "centered," remains so for all positions of the imaging system) devices perform caudal and cranial angulation along and rotation around the long axis of the stationary patient. There is no geometric distortion because the X-ray beam and film are mechanically coupled to remain perpendicular to one another.

2. Nonisocentric Unit (LAD System*). This unit allows 30° of cranial and 15° of caudal angulation of a spot film and cine camera coupled mechanically with an under the table X-ray tube. The patient must still be rotated into the desired obliquity and the heart must be "recentered" following any changes in the angulation of the X-ray tube. This system eliminates geometric distortion and has the great advantage of maintaining the radiation source shielded below the X-ray table.

B. Serial Film Changer

This was the original technique described by us utilizing a horizontal beam and lateral film changer although a vertical beam and under the table changer could also be used. This technique results in geometric distortion unless the film changer is also angulated to remain perpendicular to the X-ray beam. The technique is somewhat cumbersome because the patient must be moved to the changer from the fluoroscope and the injections made "blindly" without fluoroscopic monitoring as is usual with the cine or spot film cameras.

*General Electric

Clinical Applications

I. Cranial Angulation Projections

A. Left Coronary Artery

1. 40-60° LAO and 25-30° Cranial Angulation (left oblique clockwise table base turn [cranial], half axial RPO, half axial left ventricular angiogram, angulated beam, sit-up view, cranio-caudal sagittal angulation, lordotic LAO* projections). The main left coronary artery and its proximal branches if oriented caudally (as in most normal or slightly enlarged hearts) are better seen. The distal LAD and its branches are obscured by the diaphragm.

2. 30° RAO and 25-30° Cranial Angulation (cranio-caudal sagittal angulation* projection). This view allows better separation of the main left coronary artery and its proximal branches in enlarged hearts.

B. Right Coronary Artery

1. 30° LAO and 15° Cranial Angulation (personal observations) (left oblique clockwise table base turn [cranial], cranio-caudal sagittal angulation* projections). The distal right coronary artery and especially the vessels in the region of the crux are separated.

2. 15-30° RAO and 15-30° Cranial Angulation (personal observations). This view also provides separation of the branches at the crux.

C. Left Ventriculography

60° LAO and 30° Cranial Angulation (half axial left ventricular angiogram). The apex and the base are superimposed in the conventional 60° LAO left ventriculogram. The interventricular septum (outflow portion), the mitral valve apparatus and the posterior wall are separated and anatomically better defined by caudal angulation.

II. Caudal Angulation Projections

A. Left Coronary Artery

1. 40-60° LAO and 25-30° Caudal Angulation (left oblique anticlockwise table base turn [caudal], lordotic RPO* projections). The main left coronary artery and its proximal branches are better visualized if they take a cephalad proximal course due to cardiomegaly. In this projection, these vessels unfortunately somewhat overlap the diaphragm.

2. 15-30° RAO and 25-40° Caudal Angulation (caudo-cranial sagittal angulation*, lordotic RAO* projections). The main left, proximal LAD, and the origins of the diagonal and circumflex branches are especially well seen in this projection.

The above projections have all been useful to improve the visualization of the problem areas of both the left* and right coronary* arteries and of the left ventricle. We believe that these projections should be obtained routinely in order to avoid potentially grave errors. It is hoped that the nomenclature recommended by us will be used in the future to describe cranial and caudal angulation, and that rotation
of the patient around his long axis will be referred to as LAO
and RAO positions.

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