Z Rheumatol 58:196–200 (1999)

Đ. Babić-Naglić
K. Potočki
B. Ćurković

Clinical and radiological features of atlantoaxial joints in rheumatoid arthritis

Klinische und radiologische Besonderheiten der atlanto-axial-Gelenke bei der rheumatoiden Arthritis

Summary Atlantoaxial (AA) instability is frequent radiological finding in patients with rheumatoid arthritis (RA). Mostly no serious neurological disorders are expected in such patients.

The purpose of the study was to assess the sagittal spinal canal diameter according to Steel's rule of third and its relationship to clinical symptoms.

Radiological and clinical evaluation was performed in 65 in-patients with RA. Fifty four patients complained of neck pain, 39 had vertebrobasilar symptoms, and 25 mild neurological disorders. A hyperreflexy tendon responses were registered in 16 patients. Only 1 patient had extensor plantar response. Forward AA dislocation was verified in 28 (43%) cases with a mean value of 8.3 mm (4–17 mm). Still free space for spinal cord in spinal canal was obtained in 62 (95%) of patients, which can explain such a low incidence of serious neurological disorders.

Our results suggest an association among duration of disease, atlantodental distance, and sagittal spinal canal diameter.

We consider that it is important to detect early the most jeopardized patients on the basis of radiological analysis at C1 level according to Steel's rule of third and recognize when "safe zone" has exceeded and enters the area of impending spinal cord compression.

Received: 12 January 1998
Accepted: 20 May 1999

Đ. Babić-Naglić (✉) · B. Ćurkovic
Department of rheumatology
University hospital Rebro
Kišpatićeva 12
CRO-Zagreb 10000, Croatia

K. Potočki
Institute of radiology University
hospital Rebro
CRO-Zagreb 10000, Croatia

Zusammenfassung Atlantoaxiale (AA) Instablität ist ein häufiger radiologischer Befund bei Patienten mit rheumatoider Arthritis (RA). Meistens weisen diese Patienten keine ernsthaften neurologischen Störungen auf.

Die vorliegende Studie hatte zum Ziel, den saggitalen Durchmesser des Spinalkanals anhand der Steel'schen Ein-Drittel-Regel sowie die Relation dieses Parameters zur klinischen Symptomatik des Patienten zu bestimmen.

Radiologische und klinische Daten wurden bei 65 Patienten mit RA evaluiert. 54 Patienten klagten über Nackenschmerz, 39 zeigten eine vertebrobasilare Symptomatik und 25 hatten leichte neurologische Störungen. Verstärkte Sehnenreflexe wurden bei 16 Patienten registriert. Nur bei einem Patienten war die Reaktion plantarer Extensoren vorhanden (Babinsky-reflex). Die vordere AA Dislokation zeigten 28 (43%) der Patienten: die Verschiebung betrug im Mittel 8.3 mm (4–17 mm). Bei 62 (95%) Patienten war im Spinalkanal für das Rückenmark noch ein verbliebener freier Raum vorhanden. Dies erklärt die niedrige Inzidenz schwerwiegender neurologischer Störungen.

Unsere Ergebnisse weisen auf einen Zusammenhang zwischen der Krankheitsdauer, der atlantodentalen Entfernung und dem saggitalen Durchmesser des Spinalkanals hin. Es ist wichtig, gefährdete Patienten mit Hilfe der radiologischen Analyse des C1-Abschnitts der Halswirbelsäule frühzeitig zu erkennen. Anhand der Steel'schen Ein-Drittel-Regel kann ermittelt werden, ob die „Sicherheitszone" im Spinalkanal überschritten ist und der Patient in den Bereich einer drohenden Rückenmarkkompression eintritt.

Key words Rheumatoid arthritis – atlantoaxial joints

Schlüsselwörter Rheumatoide Arthritis – Atlantoaxialgelenke

The atlantoaxial joint are, in a way, very particular localizations of rheumatoid arthritis. In a small area there is rich net of the synovial joints, bursas and complicated ligamentous apparatus that are in very close contact with sensitive neurovascular structures. C1–C2 artriculation is the most mobile and the most instabile segment of the whole spine (4) that predispose rheumatoid affection of this area. Dislocations in all 3 planes are possible but the most frequent and early sign of the cervical RA is forward atlantoaxial subluxation described in the range from 8% to 83% rheumatoid patients (3, 5–7, 9, 12, 16, 18). The results depend on patient's selection methods. Vertical displacements are more dangerous and they are observed in 3 to 30% of patients (7, 11, 15, 16, 18). Neurological disorders can be registered in 10–15% (7, 11, 18) and myelopathy in 2.5% of patients (13). The best explanation for such a low incidence of neural complications is given by Stell's rule of third (20) that postulates that in a sagittal diameter of the atlas aperture, with the mean value of 30 mm, one third of the space occupies dens, one third spinal cord and one third is free space that allows secure movements in this region.

Magnetic resonance imaging demonstrates the bony and soft tissue changes of RA (6, 17), while somatosensory evoked potentials give information about functional integrity of the spinal cord (3, 10, 22) and there are few functional scoring systems to evaluate cervical myelopathy (8, 13) that can indicate neck surgery in time.

The purpose of this study was to determine the incidence of forward atlantoaxial subluxation and cranial settling. Also, the aim was to assess the spinal canal diameter according to Steel's rule of third to determine the free space for the spinal cord and its relationship to the clinical symptoms.

Patients and methods

Assessment was performed in 65 patients with rheumatoid arthritis (RA) who were admitted to hospital during one year. Their disease met the revised American Rheumatism Association diagnostic criteria for RA (2).

All patients whose disease lasted 5 and more years regardless of the neck symptoms as well as all patients with cervicogenic symptoms regardless of the disease duration were included in the study. Special questionaire was used for disease history for all patients.

Clinical examination was performed uniformly and range of motion of cervical spine as a whole was measured by gravitational goniometer. The range of movements of the cervical spine was examined clinically by observation and measurement of the head relative to the trunk. The movements in all planes were measured with the subject's head in neutral position and full flexion, extension, rotations and lateroflexions. Normal range of movements was tested in 40 healthy individuals aged 18 to 60 years. Of course this is not precise method regarding C1–C2 movements but clinically applicable because 50% of total cervical flexion occur in occiput and atlanoaxial joints and 50% of total cervical rotations occur in C1–C2 segment (4).

X-ray analysis included standard and lateral flexion/extension radiographs of the cervical spine and open mouth view of odontoid peg for all patients. Some patients with suspected vertical subluxation or not visualized dens epistrophei required sagittal and/or frontal tomograms.

We defined forward atlantoaxial subluxation as atlantodental distance in flexion position in the saggittal plane or more than 4 mm while vertical subluxation was considered any depiction of dens above McRae's line or 6 mm above McGregor's line. Cases with eroded or resorbed dens were described like erosions of the dens if tip of the dens did not exceeded mentioned lines. Reducible or non-stable forward atlantoaxial dislocation was registered when the atlantodental space difference between maximal flexion and extension was assesed 4 mm and more.

The values of sagittal atlas aperture and dens diameter as well as spinal canal diameter were measured on flexion lateral radiographs in the level fo tuberculum of the anterior and posterior atlas arch and registered in mm. We performed sagittal tomograms when dens was not clearly visible. Their relationships were also expressed in percentage according to Steel's rule of third. Sagittal atlas diameter represented 100% value which means that 33% occupies dens, 33% spinal cord and 33% is free space.

All data were statisticaly evaluated by t-test and factor analysis (1) with 14 entering variables.

Results

The mean duration of disease was 12.6 years (1–38 years) and the mean duration of symptoms referable to the cervical spine was 4.6 years (1 mo–19 y). Fifty four of 65 patients complained of neck pain, 39 showed vertebrobasilar complaints (dissziness, tinitus, nausea, sight disturbancies) and 25 had mild neurological symptoms (paresthesiae of occiput, arms, hands and legs, weakness of extremities). A hiperreflexy tendon response was elicited in 16 patients and only one had extensor plantar response.

Table 1 shows range of motion for 43 patients and controls. The rest of patients had either contraindication or low compliance to be measured. In patients group the mobility of neck varied from minimal to overnor-

mal. The ranges of the flexion, extension, right rotation and left lateroflexion were significantly reduced. According to this study, rotations in some cases even exceeded the normal range of motion.

Table 2 reviews the x-ray of craniocevical complex survey for all patients. Sagittal tomograms were performed in 15 patients, frontal in 10 patients and both in 5 patients. Out of 28 patients with forward atlantoaxial subluxation 19 of them had atlantodental distance ranging 4–9 mm, 9 had distance of 10–17 mm, i.e., almost 2/3 were in the "safe zone" to 10 mm of forward dislocation according to Steel's rule of third.

Also, out of 28 patients with forward atlantoaxial subluxation 17 of them had reducible and 11 of them had stable dislocation. Out of 11 patients with stable dislocation only 3 of them had fixed subluxation with no changes in the atlantodental distance during motions.

Table 3 shows absolute values of the relevant anatomical structures in atlantoaxial joints.

Absolute and proportional spatial relationships of the compromised parameters are stated in Table 4. Only 3 patients entered the risk zone of cervical cord compression with the spinal canal diameter 10 mm (less than 33% of sagittal atlas diameter) but they did not have clinically evident neurological disorders. This small number of a potentially jeopardized patients explains such a low incidence of the serious life-treatening and incapacitating neurological complications.

Table 1 Cervical spine range of motions (ROM)*

Motion	Patients X±SD N=43	Controls C±SD N=40	t-est
flexion	58±16	65±10	p<0.05
extension	50±11	60±14	p<0.05
right rotation	56±15	62±13	NS
left rotation	59±15	71±15	p<0.05
right lateroflexion	43±13	46±11	NS
left lateroflexion	40±13	46±10	p<0.05

* degrees

Table 2 Radiological features of craniovertebral junction

x-ray feature	No. of patients
forward atlantoaxial subluxation (range 4–17 mm; X=8.3; SD 3.9)	28
tip of the dens erosions	22
atlas masses laterales affection	19
basis of the dens erosion	14
axis facet joints affection	10
vertical subluxation according McGregor's line (range 6–15 mm)	9
basilar invagination according McRae's line	4
occiptial condyles affection	4

Factor statistical analysis reduced number of 14 entering variables to 5 factors that embraced 73% variability of the whole sample. This statistical method allows the use of incomplete data like the measurements of cervical spine movements for 43 out of 65 patients. Factors represent new condensed attributes for the whole group of the patients. Characteristics of factors are presented in Table 6 with factors loadings higher than 0.5 bold typed (Table 5). Factor analysis distinguished 5 factors: 3 clinical and 2 radiological factors. Clinical factors: factor 1 or factor of neck movement in sagittal and frontal plane shows independency of this movements of all other investigated variables. Factor 3 or factor of rotations shows that this movement depends on disease severity (higher amplitude of rotations is associated with higher RF titer and lower McRae's value or dens destruction). Active disease loosen ligaments in affected area that allows excessive range of motions particulary rotations because 50% of total cervical rotations are performed in atlantoaxial joints. Factor 4 or factor of neck symptoms duration separatly shows that neck symptoms could arise and exist independently of all other variables. Radiological factors: factor 2 or factor of atlantoaxial subluxation is the most specific and establishes the association among duration of disease, atlantodental distance and sagittal spinal canal diameter. This means that longer disesase duration lead to greater atlantodental distance and narrowing spinal canal. Factor 5 or factor of the McGregor's line separates this method as a common craniometrical tool that is not specific for RA.

Table 3 Measurements (mm) of anatomical structures in craniovertebral region

Structure	Patients with forward dislocation X±SD N=28	Patients without forward dislocation X±SD N=37
sagittal atlas diameter	40±4	40±4
sagittal dens diameter	11±3	13±2
sagittal spinal canal diameter	22±5	26±3
atlantodental distance	8±4	2±2

Table 4 Sagittal spinal canal diameters at level C1 (relative and absolute values)*

Spinal canal diameter (%/mm)	Patients N=65
26–33%/10 mm	3
34–66%/16–29 mm	49
67–70%/26–32 mm	13

* saggittal diameter of atlas gap represents 100% value

Table 5 Factor analysis

Variable*	F1*	F2*	F3*	F4*	F5*
1	–0.44	–0,21	–0.1	0.34	–0.27
2	–0.09	*0.74*	–0.07	0.34	–0.10
3	0.03	0.16	–0.02	*0.91*	0.10
4	0.03	0.32	*0.54*	0.22	–0.43
5	0.11	*0.88*	–0.8	0.07	0.14
6	0.09	–0.08	0.20	0.12	*0.86*
7	–0.01	0.14	*–0.69*	–0.04	–0.13
8	0.41	0.12	*0.52*	–0.38	0.37
9	0.38	–0.032	*0.68*	–0.36	0.17
10	*0.90*	–0.16	0.02	0.04	0.02
11	*0.88*	–0.15	–0.04	0.07	0.08
12	*0.68*	0.23	0.30	–0.09	0.25
13	*0.72*	0.09	0.38	–0.05	–0.20
14	0.12	*–0.77*	–0.12	0.44	0.15

* 1-age; 2-duration of disease; 3-duration of neck symptoms; 4-titer of rheumatoid factor; 5-atlantodental distance in anteflexion; 6-height of dens above McGregor's line; 7-height of dens above McRae's line; 8-right rotation; 9-left rotation; 10-right lateroflexion; 11-left lateroflexion; 12-anteflexion; 13-extension; 14-spinal canal diameter. *F1-factor of neck movement; *F2-factor of atlantoaxial subluxation; *F3-factor of rotations; *F4-factor of symptoms duration; *F5-factor of McGregor's line

Discussion

Atlantoaxial displacement is a complication of RA that can be expected in patients with longer duration of disease and neck symptoms but it can exist even in asymptomatic patients (3, 7, 9, 12, 19).

The mathematically expressed value of the atlantodental distance has no real significance like compressive factor to spinal cord in this area because this parameter does indicate pannus formation and eventual erosions of the odontoid peg or real functional value of spinal canal diameter. Therefore, we have to detect the most jeopardized patients on the basis of the analysis of functional anatomic relations in foramen magnum and antomic studies of the vertebral canal at first cervical vertebra according to Steel's rule of third. In chronic atlantoaxial instability it is important to recognize when the patient has exceeded the "safe zone" and enters the area of impending spinal cord compression. Excessive range of neck rotations can be considered as additional clinical sign of atlantoaxial instability.

We consider that the sagittal diameter of intact dens is equal to the maximally tolerable atlantodental distance. This is a rough screening method that indicates more precise and sophisticated neurophisiological and MR evaluation. It is possible to recognize false forward atlantoaxial subluxation if there are simuntaneously destructive changes of the odontoid peg (19). Also, it is possible to notice false regression of forward displacement of atlas if there is migration of dens into foramen magnum at the same time. Vertical subluxation of the upper cervical segments does not indicate protrusion of the dens into foramen magnum in all cases because the top of the dens can be eroded and thus cut down. The advantage is chronical disease process that allows spinal cord accomodation to new shape and false widens the spinal canal, which delays serious neurological damage (21).

We suggest periodical, routine clinical and radiological examination of patients with registered involvement of the atlantoaxial joints in RA to follow up spatial anatomic changes in this region in order to prevent cervical myelopathy and radiological evaluation of neck symptomless patients with disease duration of more than 5 years. With the respect to very limited value of plain x-rays this is an inexpensive and acceptable screening method that can be performed in any x-ray cabinet and gives us main morphological informations about bone structures and indirectly shows soft tissues changes.

References

1. Armitage P, Berry G (1994) Statistical Methods in Medical Research. Oxford: Blackwell Scientific Publications
2. Arnett FC, Edworthy SM, Bloch DA, McShane DJ, Fries JF, Cooper NS, Healey LA et al (1988) The American Rheumatism Association 1987. Revised criteria for the classification of rheumatoid arthritis. Arthritis Rheum 31:315–324
3. Babić-Naglić D, Nesek-Madarić V, Potočki K, Leals-Bahun N, Ćurković B (1977) Early diagnosis of rheumatoid cervical myelopathy. Scand J Rheumatol 26:247–252
4. Bland JH, Dallas RB (1990) Anatomy and physiology of the cervical spine. Arthr Rheum 1:1–20
5. Bland JH (1974) Rheumatoid arthritis of the cervical spine. J Reumatol 2:319–342
6. Breedveld FC, Algra PR, Vielvoye CJ, Cats A (1987) Magnetic resonance imaging in the evaluation of patients with rheumatoid arthritis and subluxations of the cervical spine. Arthr Rheum 30:624–629
7. Cabot A, Becker A (1978) The cervical spine in rheumatoid arthritis. Clin Orthop 131:130–140
8. Casey ATH, Bland JM, Crockard HA (1996) Development of a functional scoring system for rheumatoid arthritis patients with cervical myelopathy. Ann Rheum Dis 55:901–906
9. Conlon PW, Isdale IC, Rose BS (1996) Rheumatoid arthritis of the cervical spine. An analysis of the 333 cases. Ann Rheum Dis 25:120–126
10. Katz LM, Emsellem HA, Borenstein DG (1990) Evaluation of cervical spine inflammatory arthritis with somatosensory evoked potentials. J Rheumatol 4:508–514
11. Mathews JA (1974) Atlanto-axial subluxation in rheumatoid arthritis. A 5-year follow up. Ann Rheum Dis 33:526–531
12. Mathews JA (1969) Atlanto-axial subluxation in rheumatoid arthritis. Ann Rheum Dis 28:260–266

13. Nakano KK, Schoene WC, Baker RA, Dwson DM (1978) The cervical myelopathy associated with rheumatoid arthritis: Analysis of 32 patients, with 2 postmortem cases. Ann Neurol 3:144–151
14. Ranawat C, O'Leary P, Pellici P, Tsariris P, Marchisello P, Dorr L (1979) Cervical fusion in rheumatoid arthritis. J Bone Joint Surg 61A:1003–1010
15. Rasker JJ, Cosh JA (1978) Radiological study of cervical spine and hand in patients with rheumatoid arthritis of 15 years duration: an assesment of the effects of corticosteroid treatment. Ann Rheum Dis 37:529–535
16. Redlund-Johnell I, Petterson H (1984) Radiographic measurements of the cranio-vertebral region. Acta Radiol Diagn 25:23–28
17. Romanowski CAJ, Nisar M, Nakielny RA (1995) Atlanto-occipital subluxation in rheumatoid arthritis demonstrated by magnetic resonance imaging. Br J Rheumatol 34:787–789
18. Santavirta S, Kankaanpaa U, Sandelin J, Laasonen E, Konttinen YT, Slatis P (1987) Evaluation of patients with rheumatoid cervical spine. Scand J Rheumatol 16:9–16
19. Smith PH, Benn RT, Sharp J (1972) Natural history of rheumatoid cervical luxations. Ann Rheum Dis 31:431–439
20. Steel HH (1968) Anatomical and mechanical considerations of the atlantoaxial articulations. J Bone Surg 50:1481–1482
21. Stevens JM, Kendall BE, Crockard HA (1986) The spinal cord in rheumatoid arthritis with clinical myelopathy: a computed myelographic study. J Neurol Neurosurg Psychiatry 49:140–151
22. Toolanen G, Knibestöl M, Larsson SE, Landman K (1987) Somatosensory evoked potentials (SSEPs) in rheumatoid cervical subluxation. Scand J Rheumatol 16:17–25