Research/Recherche

Assessment of respiratory rate and chest indrawing in children with ARI by primary care physicians in Egypt

A.M. Gadomski,[1] N. Khallaf,[2] S. El Ansary,[3] & R.E. Black[4]

In a baseline study for training purposes, two indicators of acute respiratory infections (the respiratory rate (RR) and chest indrawing) were assessed by Ministry of Health physicians in Egypt using a WHO test videotape. Chest indrawing, as defined by the WHO Acute Respiratory Infections (ARI) programme, was not widely recognized by current health personnel. Viewing a WHO training videotape led to significantly more correct assessments of chest indrawing compared with a group that had not viewed this videotape.

The accuracy of using a timer versus a watch, and a 30-second versus 60-second counting interval was also evaluated. Rates counted over 60 seconds were more accurate than 30-second counts although the difference between them was not clinically significant. Counting of rates using timers with audible cues was comparable to using watches with second hands. Careful training of primary health workers in the assessment of RR and chest indrawing is essential if these clinical findings are to be used as reliable indicators in pneumonia treatment algorithms.

Introduction

Timely treatment of acute lower respiratory tract infections in children relies upon the assessment of clinical findings, especially respiratory rate (RR) and chest indrawing. Elevated RR has been shown to be an important indicator of underlying pulmonary disease such as pneumonia, asthma, bronchiolitis, and pulmonary oedema. RR has been described as a "simple and useful, although nonspecific, pulmonary function test of thoracic and pulmonary compliance" (*1*). Elevated rates, in combination with cough, have been used, and are currently being advocated by WHO, as an entry criterion for a treatment algorithm for pneumonia among infants and children.[a]

However, the measurement of RR is typically held in "low esteem" (*2*) by health workers who find that it is often a difficult and time-consuming manoeuvre, especially in infants. The conditions of crowded, noisy primary care settings also may not be conducive to counting the RR. The lure of high technology medicine also contributes to neglect of this basic clinical indicator. The use of simple instruments such as timers with audible cues has been suggested as a means of facilitating the counting of RR because the health worker does not have to look at the chest and a wrist-watch at the same time. However, the difference in accuracy between RRs counted using timers versus watches has not been assessed.

[1] Assistant Professor, Department of Pediatrics, University of Maryland, and Adjunct Assistant Professor, Department of International Health, Johns Hopkins University, School of Hygiene and Public Health, 601 N.Wolfe Street, Baltimore, MD 21205, USA. Requests for reprints should be sent to this author.

[2] Director, Acute Respiratory Infection Division, Child Survival Project, Cairo, Egypt.

[3] Programme Assistant, Acute Respiratory Infection Division, Child Survival Project, Cairo, Egypt.

[4] Chairman, Department of International Health, Johns Hopkins University, School of Hygiene and Public Health, Baltimore, MD, USA.

Reprint No. **5411**

[a] *Acute respiratory infections in children: case management in small hospitals in developing countries. A manual for doctors and other senior health workers.* Unpublished WHO document WHO/ARI/90.5, 1990.

Chest-wall indrawing, defined as an inward movement of the lower chest wall, is the key sign for referring children with severe pneumonia to hospital using the WHO Acute Respiratory Infections (ARI) treatment algorithm. However, the recognition of this sign may not be uniform among health personnel owing to varying definitions, training and experience.

In the context of instituting a national programme for the control of ARI in Egypt, ways to increase the acceptance and performance of RR counting and to assess the recognition of chest-wall indrawing were sought. The purpose of this study was (1) to briefly survey the attitudes towards and the knowledge and practices of physicians in measuring the RR, (2) to examine the effect of a training videotape on the recognition of chest indrawing, and (3) to examine the effect of using different time intervals and providing audible timers on the accuracy of RR assessment. A test videotape focused on children of different ages and breathing rates was used to conduct these assessments so that potentially modifiable aspects of counting technique alone could be addressed.

Materials and methods

Primary health care in Egypt is delivered by physicians employed by the Ministry of Health. General practitioners, paediatricians and junior doctors in primary care centres in the study area were selected randomly from a list of staff serving five governorates (Alexandria, Assiut, Cairo, Ismailia and Menoufia) targeted for the initial implementation of the ARI control programme in Egypt. The 320 physicians in this study were distributed as follows: 45% in MCH units, 30% in urban health centres, 18% in rural health units, and 7% in the district hospital or in school health. The study participants, in groups of 16 in health centres in each of the governorates, were told about the ARI programme planning and were asked to evaluate the use of audible timers versus wrist-watches in measuring the RR of infants and children.

Descriptive survey. A questionnaire was first administered to survey the physicians' attitudes and practices regarding RR measurement, their use of watches while counting, and their knowledge of the age-appropriate RR cut-offs. The study participants were anonymously surveyed about (1) how they evaluated children with ARI using two open-ended questions on history and physical examination; (2) whether or not they counted the RR, and if so, how (multiple choice); (3) what constraints they faced in counting the RR (multiple choice); and (4) what was the usual RR of children aged <2 months, 2–6 months, and 2 years (open-ended). These questionnaire data were linked with individual performances in RR counting.

Assignment to study groups (Table 1). Half the participants (Group 2) were randomly chosen to view a training videotape produced by WHO on "Assessment of the child with cough or difficult breathing". This film involves participation by viewers in counting the RRs of three children and recognizing chest indrawing in five children. During this exercise, the participants could discuss the training videotape with other participants or with the study coordinator. The control group (Group 1) viewed only the test videotape.

RR counting and recognition of chest indrawing. The test videotape of children breathing at various rates was used to compare the accuracy of the two study groups in determining the RR. This videotape, titled "Assessing maternal perception", was obtained from the WHO ARI Control Programme (Geneva) and portrays 14 infants and children with varying respiratory rates filmed for 90 seconds each. The tape shows clearly the respiratory effort and chest indrawing of the children (aged between 2 weeks and 4 years) who are identified by a number and age. The RRs of these children (range, 24 to 98 breaths per minute), obtained by counting the number of inspirations over a 60-second interval within the total 90 seconds of video observation, and the presence or absence of chest indrawing had previously been determined by experts whose observations gave the correct RR and chest-indrawing assessment.

Table 1: **Allocation of primary care physicians, by groups, to view the test videotape for RR counting and identifying chest indrawing**

	Number
Group 1: Did not view the training videotape	158
Used timer: 30-sec observation	40
Used timer: 60-sec observation	40
Used own watch: 30-sec observation	40
Used own watch: 60-sec observation	38
Group 2: Viewed the training videotape	161
Used timer: 30-sec observation	40
Used timer: 60-sec observation	39
Used own watch: 30-sec observation	41
Used own watch: 60-sec observation	41
Total	319

The physicians in the study were asked to count and record the RR of the 14 children portrayed on the test videotape. The participants were aware that the videotape segments for each child were only 90 seconds long, so they were encouraged to start counting near the beginning of the segment. Half the group were asked to count for 30 seconds and the other half for 60 seconds, as indicated on their forms. Half the group were asked to use their watches for counting, and the other half to use timers with audible cues at 0, 30 and 60 seconds. Those participants who had no watch, or only a digital watch or one without a second hand were assigned to the group using the audible cues. After recording the RR, the participants were instructed to indicate on the form whether they noted chest indrawing and/or fast breathing for each child viewed on the test video. Fast breathing was defined by the WHO recommended age-specific cut-offs.[b]

The conditions for viewing the test videotape were standardized as far as practically possible in terms of distance from the television screen, the sound volume, and the study procedures, taking into account the usual noise levels in a health centre or clinic.

The questionnaire results were entered and analysed in EPI-INFO version 5. The responses on the questionnaire were tabulated by category, including the percentage for each. The RR counts and chest indrawing data results were entered in DBASE III Plus. A joint file was analysed using SPSS-PC version 4.0. Analysis of variance was used to compare the accuracy of the four study groups in assessing the RRs. The sensitivity, specificity, and error rate (false positive plus false negative, divided by total) of the observed RR compared with the correct RR, and of chest indrawing observation compared with the correct assessment were calculated using standard formulae (*3*).

Results

During the study sessions, 318 questionnaires and 319 RR/chest indrawing assessments (one questionnaire and one assessment were not completed or lost) were available for analysis.

Questionnaire findings. The open-ended questions regarding history and physical examination used by the participants in evaluating the children with ARI yielded the following responses.

- "What kind of questions do you ask mothers of children with respiratory symptoms?" — most frequently, cough (76.5%), fever (76%), and difficulty in breathing (62%).
- "What kind of physical examination do you find helpful in evaluating a child with ARI?" — mostly, "counting the RR" (46%), "finding crepitations or rhonchi" (49%), and "dullness on percussion" (31.5%).
- "Is counting the number of breaths helpful in evaluation of children with ARI?" — 69% replied affirmatively.
- "Do you count the respiratory rates of the children with ARI that you see?" — 32% said "yes", 24% "no", and 44% "sometimes". Of those who responded "no" or "sometimes", the reasons cited for not counting the RR were the clinic is too busy (36%) or too noisy (29%), there was no training to count the RR (17.5%), and counting the RR takes too much time (17%) or is too difficult (10%).

The usual method for counting the RR was to look at the chest and at one's watch (66%); other methods were to place one's hand on the chest (15%) or to listen to the chest with a stethoscope (12%). Forty-five percent of respondents counted the respirations for 60 sec, 36% for 30 sec, 7.5% for 15 sec, and 12% said "don't know" (DK). Seventy-two percent of participants wore watches with a second hand in the clinic, and 70% responded that they had received instruction in RR assessment or ARI case management.

Open-ended responses to inquiries made regarding the "usual RR" of children were tabulated based on their falling within age-specific ranges cited in the literature (*4*). For infants <2 months of age, 72% of the responses were within the normal range of 32 to 50, 16% were outside this range, 12% of responses were "don't know" (DK). For an infant between 2 and 6 months of age, 43% of the responses were within the range of 23–42, 45% were outside this range, and 12% were DK. For two-year-olds, 52% of the responses were within the range of 18–32, 37% were outside this range, and 11% were DK.

There were no significant differences among the eight study groups (timer versus watch, each of which counted for 30 versus 60 seconds, among those who viewed and did not view the training video) with regard to their attitudes on whether the RR count is helpful, whether this count was listed in the open-ended question as being an important part of the physical examination, and whether the participant had received instruction in counting the RR or in ARI case management. The main difference among these groups was related to the fact that the partici-

[b] These cut-offs are 60 breaths per minute for infants aged <2 months, 50 for infants between 2 and 12 months, and 40 for children between 12 months and 5 years.

pants were not randomly assigned to the watch versus timer groups; thus, 89% of the watch/30-sec and 85% of the watch/60-sec groups responded that they owned watches which they used in the clinic, compared with 50% in the timer/30 and 64% in the timer/60 groups.

Recognition of chest indrawing. The correct recognition of chest indrawing between Group 1 (who had not viewed the ARI training video) and Group 2 (who had viewed it) showed that Group 1 tended to overdiagnose this condition. The difference was statistically significant in five children on the test video, all aged <1 year: Child 1, aged 8 months (20% incorrect in Group 1 versus 4% in Group 2, $P < 0.0004$); Child 5, aged 6 months (20% vs 5%, $P < 0.002$); Child 7, aged 8 months (14% vs 7%, $P < 0.04$); Child 10, 1 month (14% vs 6%, $P < 0.02$); and Child 12, aged 2 weeks (32% vs 17%, $P < 0.001$).

The sensitivity (82% ± 1.5[c]) and specificity (81% ± 1.5) of Group 2 in recognizing chest indrawing were higher and the error rate (18% ± 1.6) was lower than that of Group 1 (sensitivity, 79% ± 1.7; specificity, 75% ± 1.8; error rate, 23% ± 1.7). When two children with chest indrawing that was more difficult to recognize are removed from this analysis, the difference between Groups 1 and 2 increased (Group 1 versus 2: sensitivity, 83% ± 1.7 versus 87% ± 1.4; specificity, 78% ± 1.9 versus 87% ± 1.7; error rate, 19% ± 1.8 versus 13% ± 1.5).

RR counting. With all 14 cases in the test videotape there were no significant differences between the correct RR and the study mean or median RR, with the exception of Child 4 (aged 4 years, with RR of 98) where the very high RR led to less agreement in the RR counts. Among the study groups, there were statistically significant differences using analysis of variance in 6/14 assessments. In these six, the 60-sec groups tended to be closer to the correct RR, while the 30-sec counts tended to be higher. Overall, the median RR counted over 60 seconds was 63.7 compared with 66.5 when counted for 30 seconds and multiplied by two.

Counting over 30 seconds resulted in more RRs exceeding the cut-off values, thereby resulting in more 'false positives' (false positive rate = 193/766 (25%)) than counting over 60 seconds (false positive rate = 126/738 (17%)). However, there was no significant difference in false negative counts over 60 seconds (sensitivity = 94% ± 1.0) compared with those over 30 seconds (sensitivity = 94% ± 1.0). No significant difference was observed between groups using timers and watches in determining the RR cut-offs.

When age groups are compared, the acccuracy of RR determination is lower in those aged <2 months (sensitivity 76% ± 2.4, specificity 91% ± 1.6, error rate 16.5% ± 2.1) versus those aged 2 to 12 months (sensitivity 97% ± 1.0, specificity 91% ± 1.2, error rate 5.5% ± 1.0). Thus, the younger the child, the greater the false negative rate in determining the RR cut-off.

Discussion

This study has demonstrated significant variability in age-specific RR counting and recognition of chest indrawing among physicians. Therefore neither of these signs should be taken for granted among health personnel. The use of training videotapes appears to be an effective means of increasing the recognition of chest indrawing because it reduced both false-positive and false-negative observations of this sign.

The study found no difference in RR accuracy between groups using audible timers and watches, but may have underestimated their value. As the participants were not randomly assigned to the watch versus timer groups, there was a tendency for those who owned watches to use them during the study, and for those who did not own a watch to be assigned the use of a timer. Watch owners may have been more likely to count RRs in the past because they had the means to do it. Therefore, the timer group may have been biased towards being less experienced in counting RRs. This difference would tend to diminish the effect of timer use in accurately counting the RR and in determining whether the age-appropriate RR cut-off was attained. Therefore, our estimate of RR accuracy using a timer may be an underestimate.

The RRs counted over 30 seconds tended to be higher than those counted over 60 seconds by 2–4 breaths/minute (*5*), particularly when the RRs were high. Higher 30-second counts err on the conservative side of the treatment algorithm, i.e., they cause a greater number of RRs to pass the age-specific RR thresholds. Therefore, the error is in the direction of over-treatment rather than missing cases of pneumonia. The practical implication of more false positives is that there may be greater than necessary consumption of antibiotics by an ARI programme. Because the rates of false negatives are similar for 30- and 60-second intervals, the risk of inadequate treatment using 30-second counts is equivalent to that when using 60-second counts.

The limitations of self-reporting of knowledge, attitudes and practices (KAP) by health workers may

[c] 95% confidence interval.

include over-reporting of correct KAP which is discrepant with actual practice; however, this aspect of the study is exploratory and will be used to target the areas for future training. To better appreciate the constraints in ARI assessments as well as to evaluate actual practices, direct observation of health worker performance is required.

Sources of variability in physician assessment of both RR and chest indrawing can be reduced using 60-second counting and viewing videotaped examples of chest indrawing. As a result of this study, greater emphasis is being placed by the ARI programme on training physicians in the recognition of chest indrawing, in age-specific RR cut-offs, and in the method of RR assessment.

Acknowledgements

This study was funded by the US Agency of International Development, through a technical assistance contract of the Clark Atlanta University with the Egyptian Ministry of Health (MOH) Child Survival Project, Cairo, Egypt. We thank the MOH physicians involved in this study for their participation, and the WHO Programme for the Control of Acute Respiratory Infections for providing the videotapes and audible timers used in this study and for technical advice. Dr Gadomski was subcontracted by Johns Hopkins University for this research in Egypt.

Résumé

Estimation de la fréquence respiratoire et du tirage respiratoire par des médecins des services de soins de santé primaires en Egypte

Dans le cadre d'une étude préalable à des activités de formation, deux indicateurs des infections respiratoires aiguës (IRA), la fréquence respiratoire (FR) et le tirage respiratoire, ont été estimés par des médecins employés par le Ministère de la Santé en Egypte, au moyen d'une vidéocassette de test fournie par l'OMS. Ces estimations ont été précédées par une enquête descriptive sur les attitudes et pratiques des médecins concernant la mesure de la fréquence respiratoire, l'utilisation d'une montre pour compter cette fréquence, et la connaissance des valeurs limites selon l'âge. Au total, 319 médecins employés dans les services de soins de santé primaires de cinq gouvernorats choisis pour la mise en œuvre du programme national IRA ont participé à l'étude; 32% ont déclaré qu'ils comptaient la fréquence respiratoire des enfants atteints d'IRA, 24% qu'ils ne la comptaient pas, et 44% qu'ils la comptaient quelquefois. Les raisons avancées par les médecins qui ne mesuraient pas la fréquence respiratoire étaient: centre de soins débordé (36%) ou trop bruyant (29%), absence de formation à la mesure de la fréquence respiratoire (17,5%), fréquence respiratoire trop longue à mesurer (17%) ou trop difficile (10%). Entre un tiers et la moitié des réponses (ouvertes) aux questions concernant la fréquence respiratoire habituelle dans différents groupes d'âge chez l'enfant étaient en dehors des limites normales publiées, ce qui dénote une connaissance insuffisante des valeurs limites de la FR en fonction de l'âge.

L'observation du tirage respiratoire, tel qu'il est défini par le programme OMS des Infections respiratoires aiguës (IRA), était une pratique peu répandue parmi le personnel de santé. La projection d'une vidéocassette OMS de formation a sensiblement amélioré l'évaluation du tirage respiratoire par rapport à un groupe n'ayant pas vu cette cassette. Les médecins de ce dernier groupe tendaient à surdiagnostiquer le tirage respiratoire, par rapport à ceux qui avaient vu la cassette.

La mesure de la fréquence respiratoire sur 60 secondes était plus exacte que sur 30 secondes, mais sans différence significative sur le plan clinique. Lorsque la fréquence était comptée sur 30 secondes, la valeur obtenue dépassait plus souvent les valeurs limites, d'où un plus grand nombre de faux positifs que lors d'un comptage sur 60 secondes. L'exactitude de la fréquence respiratoire comptée avec une montre ou avec un minuteur était du même ordre. Une formation soigneuse des agents de santé primaires à la mesure de la fréquence respiratoire et à l'évaluation du tirage respiratoire est indispensable si l'on veut que ces observations soient des indicateurs fiables pour l'utilisation des algorithmes de traitement des pneumopathies.

References

1. **Kendig, E.I. & Chernick, V.**, ed. *Disorders of the respiratory tract in children*, 4th ed. Philadelphia, Saunders, 1983.
2. **Gravelyn, T.R. & Weg, I.G.** Respiratory rate as an indicator of acute respiratory dysfunction. *Journal of the American Medical Association*, **244**: 1123–1125 (1990).
3. **Sackett, D.L. et al.** *Clinical epidemiology*. Boston, Little, Brown & Co., 1985.
4. **Hoppenbrowers, T. et al.** Polygraphic studies of normal infants during the first six months of life. II. Respiratory rate and variability as a function of state. *Pediatric research*, **12**: 120–125 (1978).
5. **Berman, S. et al.** Respiratory rate and pneumonia in infancy. *Archives of disease in childhood*, **66**: 81–84 (1991).