The influence of the mass administration of diethylcarbamazine, alone or with albendazole, on the prevalence of filarial antigenaemia

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Received 25 April 2002, Revised 4 July 2002, Accepted 5 July 2002

The current Indian campaign for the elimination of lymphatic filariasis is largely based on mass drug administration (MDA). As part of this campaign, villagers in the Tirukoilur and Mugaiyur ‘blocks’ (i.e. revenue units) of Villupuram district, in Tamil Nadu, India, were treated with diethylcarbamazine (DEC), either alone (Mugaiyur) or with albendazole (Tirukoilur), in March 2001. The efficacy of treatment, in each of the two treatment arms, was evaluated by determining the percentages of the subjects who were carrying antigen from adult Wuchereria bancrofti before, 6 months and 12 months after the MDA. In a cross-sectional survey at each time-point, commercial, immunochromatographic tests were used to check 1000-1200, randomly selected, young residents (aged 2-25 years) of 18 index villages for the antigen; at least 300 villagers aged 2-9 years and at least 170 aged 10-25 years from each treatment arm were screened in each survey.

Before the MDA, 12.7% of the subjects aged 2-9 years and 23.6% of those aged 10-25 years were found to be positive for the filarial antigen. Although only about 50% of villagers aged 2-9 years were successfully treated, MDA (with DEC alone or DEC plus albendazole) led to a significant (28.7%) reduction in the prevalence of antigenaemia in this age-group 6 months later ($P < 0.05$). Although, the prevalences of antigenaemia among those aged 2-9 years were higher 12 months post-treatment than 6 months post-treatment, they were still lower (by 16%-23%) than those observed pre-treatment. The addition of albendazole to the DEC treatment appeared to offer no additional benefit in terms of the prevalence of antigenaemia in children aged <10 years; in fact, the use of DEC alone produced a slightly greater reduction in the prevalence of antigenaemia than the use of both DEC and albendazole.

In the block given MDA based on both DEC and albendazole, the prevalences of antigenaemia among the villagers aged 10-25 years were 19.4% and 16.6% lower 6 and 12 months post-treatment, respectively, than observed pre-treatment. Curiously, in the block given DEC alone, the prevalences in this age-group were higher at both post-treatment follow-ups (by 17.4% at 6 months and 33.1% at 12 months) than observed pre-treatment.

In concurrent experimental studies, high drug compliance (90%) among young children (aged 2-5 years) led to a pronounced (62.6%) reduction in the prevalence of antigenaemia after one MDA. In follow-up studies of those found antigen-positive, 40% of those aged 2-9 years but only 25% of those aged 10-25 years cleared their antigenaemias after three (annual) MDA. To maximize the benefits of MDA, greater efforts should be made to increase treatment coverage among young children.

In many communities in the developing world, it would be advantageous to treat multiple parasitic infections simultaneously. Combined therapy with diethylcarbamazine (DEC) and albendazole (ALB), for example, could help to control both intestinal geo-helminths and the nematodes causing lymphatic filariasis (Turner and Michael, 1997; Savioli et al., 1997; Ismail et al., 1998; Beach et al., 1999; Ottesen et al., 1999; Das and Pani, 2000; Stephenson and Wiselka, 2000; Küpers et al., 2001; Mafa et al., 2001; Seed, 2002).
Since 1997 there has been a large-scale campaign to eliminate lymphatic filariasis (LF) in Tamil Nadu state, in southern India. This campaign, which covers 27 million individuals in 12 districts, is largely based on one mass drug administration (MDA) each year. Until recently, DEC has been the only drug used (Ramaiah et al., 2000, 2001; Das et al., 2001a; Mani et al., 2002).

However, from the fourth MDA, in March 2001, about 50% of the target population (i.e. 14 million people in six districts) have been offered a combination of DEC and ALB. The inclusion of ALB in the DEC-based MDA is clearly beneficial in terms of the prevalences and intensities of several species of intestinal helminth (Mani et al., 2002; unpubl. obs.). It remains unclear, however, if DEC–ALB is any better than DEC alone in reducing the morbidity associated with LF. The seroprevalences of antigenaemia with antigen of adult Wuchereria bancrofti — usually described simply as antigenaemia prevalence or AGP — were investigated in nine villages in Tamil Nadu in 1995–1999, before and after various interventions designed to control LF (Sunish et al., 2002). There have also been studies in the state on the changes in AGP and on antigenaemia clearance between 1999 and 2002 (unpubl. obs.). 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The effect of MDA with the DEC–ALB combination on human infection with the parasites causing LF, as reflected in the AGP, needs to be studied in a large-scale programme before use of the combination is extended to the at-risk populations in all endemic areas. The aim of the present study was to follow the trends in AGP in the year following one MDA based on DEC–ALB and compare them with those seen following one MDA based on DEC alone.

SUBJECTS AND METHODS

The study area and population, which fall within the area covered by Tamil Nadu's campaign for the elimination of LF, have already been described (Mani et al., 2002). The present investigation formed part of an ongoing, longitudinal-cum-cross-sectional study, in two ‘blocks’ (i.e. revenue units) in the Villupuram district of Tamil Nadu. Together, the two study blocks, Tirukoilur and Mugaiyur, have a population of 321,000 residing in 204 villages. At the start of the main study, 51 of these 204 villages were screened for the selection of 18 index villages, with stratification for village size and mean levels of microfilaraemia (Mani et al., 2002). Several parameters (parasitological, entomological and programme variables) relevant to the campaign are being investigated in these index villages. In MDA on 19–24 March 2001, each resident of Tirukoilur and Mugaiyur (excluding those aged <2 years and pregnant women) was scheduled to receive only 6 mg DEC/kg (Mugaiyur) or the same dose of DEC plus 400 mg ALB (Tirukoilur). In each block, attempts were made to encourage good compliance with a well orchestrated campaign of information, education and communication (Mani et al., 2002). At each of three time-points (immediately before and 6 and 12 months after the MDA), blood samples from those aged 2–25 years in about 10% of the households in both blocks (selected at random at each time-point) were tested for adult W. bancrofti antigen, using one of two commercial immunochromatographic tests (ICT) — either the ICT Filariasis Test (AMRAD ICT, Richmond, Victoria, Australia) or NOW® ICT (Binax, Portland, ME). A neighbouring household with similar social attributes was investigated if a selected household was unavailable. Sampling was continued until at least 300 subjects aged 2–9 years and at least 170 aged 10–25 years had been tested for antigen at each time-point.

AGP were calculated separately for the subjects aged 2–9 and 10–25 years and then used to estimate AGP for a ‘standardized population’ of 2040 subjects aged 2–25 years (680 aged 2–9 years and 1360 aged...
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The data were analysed using two statistical packages: version 4.0.1 of SPSS/PC+ (SPSS, Chicago, IL) and version 6.0 of Epi Info (Centers for Disease Control and Prevention, Atlanta, GA). The changes (%) in AGP from time zero to 6 and 12 months post-MDA were computed and compared, between age-groups and between treatment arms, in \( \chi^2 \) tests.

The study protocol was approved by the ethical committee of the Centre for Research in Medical Entomology (CRME) in Madurai.

**RESULTS**

Compliance (in each treatment arm and each age-group considered) was only 53%. The AGP values recorded, at each of the three time-points, for subjects aged 2-9 or 10-25 years are presented, for each treatment arm and for both treatments combined, in Table 1. In the pre-MDA assays, the AGP in each treatment arm were similar for those aged 2-9 years but those aged 10-25 years who were scheduled to receive DEC alone had significantly lower AGP than their counterparts who were scheduled to receive DEC–ALB (19.07% v. 29.24%; \( P < 0.05 \)).

For the subjects aged 2-9 years, the AGP recorded in both (post-MDA) follow-up surveys were lower than those recorded pre-MDA, and lower in the DEC arm than in the DEC–ALB arm at each survey (Table 1). The decrease in the prevalence of antigenaemia apparently induced by the MDA was greater 6 months after the administration than at 12 months (Table 1).

For the subjects aged 10-25 years who were investigated, AGP fell (DEC–ALB) or rose (DEC) after the MDA, according to the drug(s) used (Table 1). However, these trends were set by the pre-MDA prevalences (much higher for the DEC–ALB arm than for the DEC) rather than the between-treatment differences in the AGP recorded at each survey after the MDA (neither of which was statistically significant; Table 1).

The data for the two treatment arms were therefore pooled to show trends for MDA with DEC as the ‘core’ drug (i.e. with or without ALB). When this was done, it appeared that a single MDA only had a significant effect on AGP (within 1 year) in the youngest subjects (aged 2–9 years), with a 28.7% reduction in this prevalence after 6 months and a 19.7% reduction after 12 months (Table 2). In those aged 10–25 years, DEC-based MDA appeared to lead to a much smaller reduction or even an increase in AGP (Table 2). Overall, the AGP for the ‘standardized population’ of 2040 subjects aged 2–25 years (which was dominated by subjects aged 10–25 years, among whom MDA had less effect than it did among their younger neighbours) only showed a 9.0% decrease in AGP at 6 months and a small (and insignificant) increase after 12 months (Table 2).

**DISCUSSION**

The campaign for the elimination of LF is in full swing in Tamil Nadu, India, with >27 million individuals targeted in the fifth annual MDA, in March 2002 (unpubl. obs.). In the present study, based on the fourth MDA, any subject found antigen-positive in the ICT was assumed to be carrying at least one adult *W. bancrofti*. A reduction in AGP within a year of the MDA was taken to reflect the adulticidal efficacy of the drug or drugs used. Immediately before the MDA, those aged 10–25 years were almost twice as likely to be worm-positive as those aged 2–9 years (23.6% v. 12.7%). Six months after the MDA, the drug administration appeared to have had a much greater effect on the adult worm burden of those aged 2–9 years (23.6% v. 12.7%). The same trend was still apparent at the 12-month follow-up (Table 2). This difference between age-groups was seen to be even more marked in
TABLE 1. Changes in the prevalence of antigenaemia (AGP) in two age-groups after a mass drug administration (MDA) based on diethylcarbamazine (DEC) alone or a combination of DEC and albendazole (DEC–ALB)

<table>
<thead>
<tr>
<th>Evaluation period</th>
<th>Subjects aged 2–9 years</th>
<th>No. of subjects and (% prevalence)</th>
<th>% change in AGP from the pre-MDA level</th>
<th>Subjects aged 10–25 years</th>
<th>No. of subjects and (% prevalence)</th>
<th>% change in AGP from the pre-MDA level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>DEC–ALB</td>
<td>DEC alone</td>
<td>DEC–ALB</td>
<td>DEC alone</td>
<td>DEC–ALB</td>
</tr>
<tr>
<td>Pre-MDA</td>
<td></td>
<td>290 (12.76)</td>
<td>338 (12.72)</td>
<td>–</td>
<td>–</td>
<td>171 (29.24)</td>
</tr>
<tr>
<td>6 months post-MDA</td>
<td></td>
<td>303 (9.90)</td>
<td>379 (8.44)</td>
<td>–22.4</td>
<td>–33.7</td>
<td>229 (23.58)</td>
</tr>
<tr>
<td>12 months post-MDA</td>
<td></td>
<td>297 (10.77)</td>
<td>368 (9.78)</td>
<td>–15.6</td>
<td>–23.1</td>
<td>168 (24.40)</td>
</tr>
</tbody>
</table>

*Before the MDA, 12.74% of the 628 subjects aged 2–9 years and 23.58% of the 386 aged 10–25 years were found antigen-positive.
†This prevalence of antigenaemia was significantly lower than that recorded for the subjects of the same age-group who were scheduled to receive DEC–ALB (P < 0.05).

TABLE 2. The prevalences of antigenaemia (AGP) for both treatment arms combined, and the estimated prevalences for a standardized population of 680 2- to 9-year-olds and 1360 10- to 25-year-olds

<table>
<thead>
<tr>
<th>Evaluation period</th>
<th>Subjects aged 2–9 years</th>
<th>No. of subjects and (% prevalence)</th>
<th>% change in AGP from the pre-MDA level</th>
<th>Subjects aged 10–25 years</th>
<th>No. of subjects and (% prevalence)</th>
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</tr>
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<tr>
<td></td>
<td></td>
<td>No. (%)</td>
<td>% prevalence</td>
<td>No. (%)</td>
<td>% prevalence</td>
<td></td>
</tr>
<tr>
<td>Pre-MDA</td>
<td></td>
<td>628 (12.74)</td>
<td>–</td>
<td>386 (23.58)</td>
<td>–2.8</td>
<td></td>
</tr>
<tr>
<td>6 months post-MDA</td>
<td></td>
<td>682 (9.09)</td>
<td>–28.7*</td>
<td>506 (22.92)</td>
<td>+6.6</td>
<td></td>
</tr>
<tr>
<td>12 months post-MDA</td>
<td></td>
<td>665 (10.23)</td>
<td>–19.7</td>
<td>362 (25.14)</td>
<td>–9.0</td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant change (P < 0.05).
a concurrent experimental study in the same area of India (unpubl. obs.). Then, a single, DEC-based MDA was found to be enough to cut AGP in those aged 2–5 years by more than half, from 9.5% (N = 464) to 3.6% (N = 479; χ² = 12.8; P < 0.001), whereas the AGP among those aged 15–25 years fell only marginally, from 22.3% (N = 409) to 21.7% (N = 401). However, the treatments in this experimental study were actively supervised by the researchers and compliance was >90%. In the present study, which was run using the routine procedures of the state-level campaign for the elimination of LF, compliance was much poorer (53%). If the campaign is to be successful, compliance must be increased.

When 223 individuals [from the nine villages described by Sunish et al. (2002)] who had been found antigen-positive in 1999 were re-tested in 2002, after three annual MDA, 18 (40%) of the 45 who were aged 2–5 years in 1999 but only 41 (23.0%) of the 178 aged 15–25 years in 1999 were found to have cleared their antigenaemias (χ² = 5.31; P < 0.05; unpubl. obs.). Thus, there is evidence that, in terms of AGP over one or three MDA, DEC has the greatest effect on the youngest villagers eligible for treatment (i.e. those aged 2–5 years).

The observation that, among those aged 10–25 years who were studied before the MDA, those in Mugaiyur (scheduled to receive just DEC) had a significantly lower AGP than their counterparts in Tirukoilur (who were scheduled to receive DEC–ALB) is surprising, especially as there was no comparable difference in the younger subjects. The unusually low (pre-MDA) AGP recorded in Mugaiyur may not reflect the MDA in all the villagers aged 10–25 years. Six or 12 months after the MDA, the 10- to 25-year-olds from Mugaiyur had very similar AGP to those from Tirukoilur. It seems unlikely that the MDA based on DEC alone triggered a 30% increase in AGP (even though the present results indicate such an increase), especially as the MDA based on DEC–ALB apparently led to a decrease in AGP. A longitudinal study of the same subjects over time may have given a better idea of the true trends in AGP.

The present results, particularly those for the youngest subjects (aged 2–9 years), indicate that the addition of ALB to a DEC-based MDA offers no advantages in terms of human infection with adult *W. bancrofti*. That AGP recorded 12 months after the MDA were higher than those recorded at 6 months is probably evidence of new infections after the drug administration. Transmission of *W. bancrofti* in the study area resumed within 3 months of the MDA (as recorded by entomological monitoring) and continued, albeit at a lower level than observed pre-MDA, for at least the next 9 months (I. P. Sunish, unpubl. obs.).

Most studies on antigenaemia after DEC treatment have not used children as subjects but adults (with relatively high antigen concentrations). A standard dose of DEC (72 mg/kg, spread over 12 days) was found insufficient to clear antigenaemia completely (Weil et al., 1988; Day et al., 1991) and detectable adult-worm antigenaemia may persist after a single dose or even 12 weekly doses of DEC (Eberhard et al., 1997). Only 26% of the antigen-positive patients treated by Freedman et al. (2001), with an aggressive course of DEC (i.e. four standard treatments at six-monthly intervals), were found to be antigen-negative 2 years after the first dose. Although Ismail et al. (2001) found that antigen concentrations were markedly reduced following treatment with a single combined dose of DEC (6 mg/kg) and ALB (400 mg), none of the patients they treated (who were aged 18–55 years) became antigen-negative during follow-up. Although the present study was not longitudinal and treatment compliance was not very good, the decreases seen in AGP indicate that some of the subjects (all aged <26 years) did clear their antigenaemias after a single-dose MDA.

Not only do young children tend to have lower AGP than other age-groups, but also only 10%–20% of antigen-positive young children are microfilaraemic (Lammie et al.,
1994, 1998; Simonsen et al., 1996; Ravindran et al., 2000; Sunish et al., 2001; Witt and Ottesen, 2001), and antigen-positive young children have relatively low antigen concentrations (Tisch et al., 2001). In fact, most antigen-positive microfilaraemics have relatively low antigen concentrations (Chanteau et al., 1994; Nicolas 1997). Age and sex were both found to be related to antigen concentrations in the Cook Islands (Steel et al., 2001). Surprisingly, even in areas with marked seasonal variation in transmission intensities, antigen concentrations are remarkably stable (Jaoko et al., 2001).

The localization of adult filarial worms appears to vary with the age of the human host and particularly with puberty (Dreyer et al., 1999; Witt and Ottesen, 2001). Children and adults may therefore carry adult worms in different places. Although it remains unclear if localization affects susceptibility to treatment, some adult worms do appear to be relatively insusceptible to treatment with antifilarial drugs (Eberhard et al., 1991; Noroes et al., 1997). Noroes et al. (1997) and Freeman et al. (2001) suggested that the percentage of adult worms susceptible to treatment with DEC varied with the age of the host, such that infections in pre-pubescent children were particularly susceptible. Although young children have relatively low worm burdens, the present results indicate that the adult worms they do carry are more susceptible to DEC-based MDA than those carried by older villagers. Efforts to increase compliance should therefore perhaps be focussed on young children.

The World Health Assembly, World Health Organization and Global Alliance hoped that human filariasis could be eliminated globally, by 2020, if 80%-90% of those living in at-risk communities could be treated in annual MDA for 5–6 years (Ottesen et al., 1999; WHO, 1999, 2000; Karam and Ottesen, 2000; Das et al., 2001a, b; Sunish et al., 2002). An AGP threshold in children, of 0.1%, was proposed as the criterion for confirming the elimination of LF in a given region (WHO, 1999). Sunish et al. (2002) recently reported that, in three villages in the present study area, annual MDA in 1995 and 1996, combined with vector-control measures from 1995–1999, led to a much lower AGP by 1999 amongst children aged 2–5 years than seen in three control villages (5.3% v. 14.7%). This success was achieved even though children aged 2–5 years were not included in the two MDA. Three further MDA with good (90%) compliance and treatment targeted at all villages aged ≥2 years, in 1999, 2000 and 2001, have since reduced the AGP in the 2- to 5-year-olds even further (to 3.6% in 2002; unpubl. obs.).

Poor treatment coverage and even poorer compliance remain problems in the elimination campaign in Tamil Nadu (Ramaiyah et al., 2000; present study). In the state-wide MDA in 1999, treatment was only available to 74% of the at-risk population, although this represents an improvement on the coverage in previous years (Das et al., 2001a). In the present study villages, only about one subject out of every two who had access to DEC or DEC–ALB in the MDA in 2001 actually took the drug(s). The main reasons for non-compliance were found to be poor awareness of the benefits of taking DEC, adverse reactions, the distribution of ‘too many’ tablets, and forgetfulness (Das et al., 2001a; unpubl. obs.). In Villupuram district, it has taken four MDA for the control programme administered by the public-health system to reduce AGP to 10.2% in 6- to 9-year-olds and to 7.0% in those aged 2–5 years (unpubl. obs.). Compliance clearly needs to be improved — probably by targeting health-education at all of the ‘stakeholders’ (including mothers, to improve coverage of children) — if 80%-90% of the individuals at-risk are to be treated and an AGP of ≤0.1% in children is to be achieved.

Although the addition of ALB to DEC treatment appears to offer no benefits in terms of AGP, it has the significant advantage of reducing the prevalences and intensities of infection with geohelminths for at least 11 months after the MDA (Mani et al., 2002; unpubl. obs.). For the control of multiple
parasitic infections at the community level, the addition of ALB to DEC is a useful and beneficial strategy.

ACKNOWLEDGEMENTS. The current study was financially supported by WHO/TDR (grant A00257). The authors are grateful to Dr R. Reuben, former Director of CRME, for her constant encouragement and guidance throughout the study, and the staff of the Department of Public Health and Preventive Medicine, Government of Tamil Nadu, Chennai, for their support during the course of our studies. The technical assistance of Shri R. Krishnamoorthi, and other members of the CRME staff in Tirukoilur and Madurai is gratefully acknowledged. We also appreciate the excellent help rendered by Shri A. Venkatesh and A. Susila, in the preparation of this manuscript.

REFERENCES


