The Translocation t(4;14) Can Be Present Only in Minor Subclones in Multiple Myeloma

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Abstract

**Purpose:** Although the translocation t(4;14) is supposed to be a primary event in multiple myeloma, we have been surprised to observe that in large relapse series of patients, the t(4;14) can be observed only in subpopulations of plasma cells, in contrast to what is seen at diagnosis. This observation raised the question of possible subclones harboring the translocation that would be observable only at the time of relapse.

**Experimental Design:** To address this issue, we analyzed by FISH a cohort of 306 patients for whom we had at least two samples obtained at different disease phases.

**Results:** We observed a "gain" of the t(4;14) in 14 patients, and conversely, a "loss" of the translocation in 11 patients. Two hypotheses were raised: either an acquisition of the translocation during evolution or the existence of small t(4;14)-positive subclones at the time of diagnosis. To address this question, we had the opportunity to analyze two patients at the time of diagnosis by RT-PCR (reverse transcription-polymerase chain reaction) to look for the chimeric Eμ-MMSET transcript, and one patient positive at diagnosis, but negative at relapse. The samples were positive, supporting the second hypothesis. Furthermore, the IGH sequences of two patients who "lose" the t(4;14) were identical at diagnosis and relapse, confirming the existence of a common ancestral clone.

**Conclusion:** Thus, the conclusion of this study is that the t(4;14) is not a primary event in multiple myeloma and that it can be present in silent subclones at diagnosis, but also at relapse. Clin Cancer Res; 19(17); 4634-7. ©2013 AACR.
This latter model raises the question whether IGH translocations could be present at diagnosis only in minor subclones but present in the major clone at progression. To even more support this hypothesis, we have been surprised to observe in large relapse trials that the t(4;14) translocation could be observed only in subpopulations, in contrast to what is observed at diagnosis. To definitely address this issue, we decided to screen for t(4;14) a large cohort of patients for whom diagnostic and relapse samples were available.

**Patients, Materials, and Methods**

We first searched in the IFM database for patients with at least 2 samples obtained at different times of the disease history. We found 306 patients responding to this criterion. They were 38% females and 62% males, with a median age of 57 years (range, 47–74). Eighty-five percent of them were treated at diagnosis with intensive approaches at diagnosis. Eighty-two percent received a VAD induction (Vincristine–Adriamycin–Dexamethasone), and 18% received a bortezomib-based induction. Fifteen percent of the patients (median age, 72 years; range, 66–74) received a melphalan-prednisone (MP)-based treatment, combined with either thalidomide (19 patients) or with bortezomib (25 patients). Among these 306 patients, 38 presented a t(4;14) at diagnosis.

For all the patients, a bone marrow aspirate was shipped to the central laboratory using overnight courier. Upon receipt, mononuclear bone marrow cells were separated using Ficol-Hypaque. Then, plasma cells were sorted using anti-CD138–coated magnetic beads (Miltenyi Biotec or StemCell Technologies). Only samples with at least 90% of plasma cells were kept for further analyses. FISH was conducted as previously described (6). Briefly, sorted plasma cells were fixed in Carnoy’s fixative and stored at −20°C until hybridization. After slide preparation, they were denatured in 70% formamide for 5 minutes, dehydrated in 70%, 85%, and 100% ethanol series. The probe specific for the t(4;14) was purchased from Abbott Molecular and denatured separately for 5 minutes at 75°C. After denaturation, the probe was dropped on the plasma cells and hybridized overnight at 37°C. Then, coverslips were removed and the slides were washed 2 minutes in 2× SSC-0.1% Triton at 75°C. All the relapse samples were analyzed for the t(4;14), independently of the diagnosis result. For RT-PCR analyses, we used specific primers for IGH and MMSET, as previously described by Malderini (7). Finally, IGH sequences were conducted according to routine practice.

**Discussion**

During the past decade, important efforts have been produced to understand the oncogenesis of multiple myeloma (8–12). Essentially based on gene expression profiling data, several classifications have been proposed (13–15). The most powerful model has been proposed by Bergsagel and colleagues (2). This model does identify primary and secondary genetic events. Early oncogenesis is driven by 2 different (almost) exclusive genetic events: gains of whole chromosomes leading to hyperdiploidy and translocations involving the IGH gene at 14q32. These latter events are supposed to occur by errors during the VDJ rearrangements, whereas hyperdiploidy cause is not known. This model is experimentally confirmed by the observation that IGH translocations are present in the large majority of the plasma cells at diagnosis, in agreement with a primary event. Data are less demonstrated for hyperdiploidy as hyperdiploidy is not routinely analyzed at diagnosis.

During the past year, 2 groups (IFM and Mayo Clinic) did show another level of heterogeneity at the patient level (3–5). They showed that relapses are sometimes due to clones related but different from the diagnosis clone. Furthermore, with time, different clones are responsible for the different relapses and maybe selected by the various treatments used at each phase. Whether these findings modify the previous oncogenetic model is not sure. It is totally conceivable that the primary events occur in the ancestral clone, as shown in
Egan’s paper (4), showing that the t(4;14) was present in all subclones.

Our data significantly modify these concepts. Primarily, we have been alerted by the fact that in relapse trials including cytogenetic analyses, the t(4;14), when present, was often observed in only subclones (sometimes as few as 30%), in contrast to the situation seen at diagnosis. As cytogenetics at diagnosis was not available, 3 hypotheses were raised. The first one was that the t(4;14) was present at diagnosis but lost in some plasma cells at relapse because of subsequent chromosomal rearrangements that could affect the der(4) chromosome. The second hypothesis was the absence of the t(4;14) at diagnosis, and the acquisition of the translocation during evolution. Finally, the third hypothesis was the existence of subclones and that the original principal clone was not the one harboring the t (4;14). Whereas the first hypothesis was compatible with the Bergsagel and Kuehl’s model, the 2 others were not compatible with a primary event.

To address this important question, we did select patients for whom at least 2 samples were available in the IFM biobank. We identified 306 patients responding to this condition. All of them have been tested at diagnosis for the t(4;14), which was found in 12.4% of the patients. We conducted FISH for the t(4;14) on all the relapse samples. The data confirmed our first hypothesis that the t(4;14) can be observed only at relapse but also that it can disappear at relapse, at least at the FISH level. Thus, only the 2 last hypotheses were still plausible. The only way to answer this question was to use a sensitive method to test the presence of the t(4;14) in minor subclones at diagnosis. We found 2 patients for whom non-fixed frozen plasma cells from the diagnosis were available. Using sensitive RT-PCR, we detected the chimeric Eμ-MMSET transcript specific of the t(4;14), confirming the third hypothesis, at least in these patients. We also had the opportunity to test one patient in whom the t(4;14) was not detected at the time of relapse, although present at diagnosis. The RT-PCR analysis for IGH-MMSET confirmed the presence of the rearrangement in some cells in the relapse sample. Finally, to definitely show this subclonal hypothesis and to eliminate the possibility of the occurrence of a second myeloma (and also a possible mix in the FISH slides), we did show in 3 patients that the IGH sequences were exactly the same at both time points.

Our data have important implications. First, they clearly show that the t(4;14) is not a “primary” event, in the genetic sense. In these cases with occurrence at relapse, or disappearance at relapse, the translocation is not present in the ancestral clone. So the model should be reconsidered (Fig. 1). Second, although the t(4;14) is supposed to confer aggressiveness, it can become apparent only at the time of relapse. What are the mechanisms that control this supposedly aggressive clone is not known. In contrast, the t(4;14)
can be present at diagnosis but “lost” at the time of relapse. Whether the t(4;14) subclone has been eliminated by the chemotherapy or just silenced until next relapse is an unanswered question. In one patient, we showed that the t(4;14) subclone was still present at relapse, even if not detectable by FISH. These issues may have important consequences for the management of the patients. For instance, are these “secondary” clones as aggressive as the ones seen at diagnosis? To conclude, our data bring another level of complexity in an already complex disease.

Disclosure of Potential Conflicts of Interest
X. Leleu is a consultant/advisory board member of Celgene, Onyx, Jansen, Novartis, Angen, and Millenium. G. Marit has expert testimony from Jansen Cilag (IMW 2011; ASH 2012). L. Karlin has honoraria from speakers’ bureau of Celgene and Janssen and is also a consultant/advisory board member of Celgene. No potential conflicts of interest were disclosed by the other authors.

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